PART-III
Productivity is generally used to express the power of agriculture in a particular region to produce crops, no matter whether that power is natural or due to the efforts of man. It is not a synonym of 'fertility', because fertility denotes the ability of soil to produce all the essential plant nutrients in available form and a suitable balance for the plant growth.¹

Agricultural productivity may be defined as the ratio of the index of total agricultural output to the index of total input used in farm production. It is, therefore, a measure of efficiency with which inputs are utilised in production, other things being equal. According to Dewett, "Productivity expresses the varying relationship between agricultural output and one of the major input, like land or labour or capital, other complements factors remaining the same..." It may be born in mind, that productivity is physical rather than a value concept.²

The analysis of agricultural productivity has attracted the attention of many geographers and economists. Many attempts have been made to measure agricultural productivity in India as well as in other countries of the world. In measuring the relative productivity of British and Danish farming, Thompson\(^3\) (1926) emphasized and expressed it in terms of gross output of crops and livestock. For this he considered the following seven parameters: (i) the yield per unit area of crops, (ii) the livestock per 100 unit area, (iii) the gross production or output per 100 unit area (iv) the proportion of arable land, (v) the number of persons employed, (vi) the cost of production expressed in terms of wages and labour costs rent or interest, and (vii) prices relative profitability and general economic conditions.

Ganguli\(^4\) (1938) presented a theoretical discussion for assessment of agricultural productivity. Firstly, he took into account the area under any crop 'A' in a particular unit area belonging to a certain region. This area is expressed as a proportion of the total cropped area under all the selected crops. Secondly, he tried to calculate the yield index number. This he did by dividing the yield per hectare for the entire region as the standard. This yield may be

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expressed as a percentage and to this percentage he termed as yield index number. Thirdly, the proportion of the area under crop 'A' and the corresponding index number of yield were multiplied. The product thus obtained indicates actually an index of contribution of the crop 'A' to the productivity of the unit area considered.

Kendall (1939) treated the productivity measurement as a mathematical problem and initiated a system of four coefficients (a) productivity coefficient, (b) ranking coefficient, (c) money value coefficient and (d) starch equivalent or energy coefficient. He said that the productivity coefficient and the ranking coefficient are concerned only with the yield per unit area, but are not in any way weighted according to the volume of production. Kendall, therefore, evolve a measure of crop productivity by using index number technique. In this technique the yield of different crops should be expressed in terms of some common units. He pointed out two common units: first money value 'as expressed in price' and second energy 'as expressed in starch equivalent'.

Money value index has a major difficulty of non-availability of price list of some of the vegetables which the

farmers grow for their household consumption. Secondly, large variation in the price of agricultural produce from the area where it is produced to the other areas of consumption. Kendall, therefore, suggested starch equivalent as the most suitable unit. While calculating a coefficient based on starch equivalent, the question arises, whether the gross starch equivalent of the various crops should be considered or the net equivalent. Net energy refers to the amount of energy for work and body building whereas, a gross figure includes the energy used in digestive process of the consuming animals and similar non-realisable forms. Kendall suggested that production of energy be preferred as the gross energy.

The measurement of productivity by the productivity coefficient method involves the use of high mathematics, and the money value coefficient and starch equivalent of energy coefficient poses a partial difficulty. Therefore, Kendall looked for a coefficient which might lead to similar results in productivity and save a good deal of calculations. The method attempts to arrange in sequence of any given number of units growing the same range of crops and then assess their agricultural productivity. Kendall took the acre yields of ten leading crops in each of the forty eight administrative counties of England for four selected years. The places occupied by each county with respect to selected
crops were then averaged, and thus ranking coefficient of agricultural productivity of each county was obtained. If a county was at the top of every list, it would have a ranking coefficient of one and if it were at the bottom of every list, it would have a ranking coefficient equal to the number of counties taken into consideration.

Hirsch (1943) has suggested, 'Crop Yield Index' as the basis of productivity measurement. It expresses the average of the yield of various crops on a farm or in a locality relative to the yield of the same crops on another farm in a second locality.

Stamp (1952) applied Kendall's ranking coefficient technique on an international level in order to determine agricultural productivity of a number of countries as well as some major crops.

Stamp (1958) suggested another method for measuring agricultural productivity, i.e., to convert the total agricultural production in calories. The caloric intake is a measure of the general health of a person because it determines

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the amount of heat and energy needed by the human body. Taking into consideration the age and structure of population, its occupation, the weight and height of the people living under climatic conditions of north-western Europe the average caloric requirement is 2,460 per day or about 9,00,000 calories a year. Stamp called it as a Standard Nutrition Unit.

Shafi\(^9\) (1960) applied the technique 'ranking coefficient' of Kendall for measuring agricultural efficiency in Uttar Pradesh taking into account eight food crops grown in each of the forty eight districts of the state. He applied this method to acre yield figure for the two quinquennial years ending 1952 and 1957.

Mackenzie\(^10\) (1962) has measured agricultural productivity of Canadian agriculture by using the coefficient of output relative to input. He mentions that concept of productivity measurement is difficult to define and even more difficult to quantity.

---


Enyedi\(^{11}\) (1964) while describing geographical type of agriculture in Hungary refers to a formula for determining agricultural productivity. His formula for assessing productivity coefficient would be read thus:

\[
\frac{Y}{Y_n} = \frac{T}{T_n}
\]

where

\(Y\) = total yield of the respective crop in the unit area,
\(Y_n\) = total yield of the crop at the national level.
\(T\) = total cropped area of the unit,
\(T_n\) = total cropped area at the national level.

Chaterji and Maitreya\(^{12}\) (1964) have determined the level of agricultural development and productivity during 1950-51 to 1957-58 in the state of West Bengal, considering only two principle crops, viz., paddy among the food crops and jute from cash crops. They utilized the acre yield figure for this study.

Aggarwal\(^{13}\) (1965) has suggested 'Factorial Approach', while measuring agricultural efficiency of Bastar districts

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of Madhya Pradesh. In this approach a number of human controlled factors relating to agricultural production as: Crop superiority, crop commercialization, crop security, land use intensity and power input have been selected, excluding the environmental factors.


W. Y. Yang (1965) has calculated the yield of different crops in a farm and compared it with the average crop yield.
of the whole region under study. Later on a value in percentage is obtained by dividing the yield per hectare of a crop in a particular farm by the average yield of the crop in the entire region. The value obtained is multiplied by 100, gives the index number. By considering the area devoted to each crop as a weight and multiplying this by percentage index, the products are obtained and by adding the products and dividing the sum of the products by the total cropped area in the farm, the average index thus obtained is the desired crop index for the particular farm, using crop as weight.

All the above mentioned studies have a common goal to find ways and means for increasing agricultural productivity either through the application of higher degree of modern inputs or through changing the methods of production.

In the present study the productivity indices have been calculated on the basis of Yang's Crop Yield formula for the two periods of time, i.e., 1975-76 and 1985-86. All the major crops of the area are taken into account. These crops are rice, wheat, maize, barley, jwar, bajra, black gram, green gram, lentil, gram, peas, pigeon pea, mustard, line seed, til, sugarcane and potato. For the sake of convenience all the above mentioned seventeen crops grown in the region are categorized into four major groups, i.e., (a) Cereals, which include rice, wheat, maize, barley, jwar and bajra. (b) Pulse,
include all the pulse crops such as black gram (urd),
green gram (moong), lentil (masoor), gram, peas and pigeon
peas. (c) Oil seeds, which include mustard, linseed and
til, and lastly (d) Cash crops, such as sugarcane and potato.

The data for the study has been collected from the
published records of the Directorate of Agricultural Statis-
tics and Crop Insurance, Krishi Bhawan and from the Institute
of State Planning, Jawahar Bhawan, Lucknow, Uttar Pradesh
for the year 1975-76 and 1985-86, taking Community Development Block as a unit. Great care has been taken to ensure
the accuracy and reliability of the statistical informations
obtained. The block-wise indices of crop productivity were
computed according to the methodology as given by Yang and
is explained by the author taking an example of Ghatampur block
of Kanpur district (Table 36). This index represents
the yield of the crops in the block compared with the average
yield of the crops in the lower Ganga-Yamuna Doab.

For calculating the crop yield index for a block, the
average yield of each crop grown in the lower Ganga-Yamuna
Doab must be determined. After that, percentage value of the
crop yield in the block is calculated by dividing the yield
per hectare of the crops in the whole lower Doab. This
calculated value gives the index number of the crop yield in
the block as shown in Table 36. This percentage value of
## Method of Calculating Crop Productivity Index (Cereals)

### For Ghatampur Block

<table>
<thead>
<tr>
<th>Name of the Crop</th>
<th>Yield in quintal/hect.</th>
<th>Area of the crop in the block in hectare</th>
<th>Crop yield in the block as percentage of the Lower Ganga-Yamuna Doab (Col. 3/Col. 2 x 100)</th>
<th>Percentage multiplied by area in hect. (Col. 5 x Col. 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>21.56</td>
<td>10280</td>
<td>111.78</td>
<td>114,909.84</td>
</tr>
<tr>
<td>Rice</td>
<td>15.08</td>
<td>2292</td>
<td>110.54</td>
<td>253,357.68</td>
</tr>
<tr>
<td>Maize</td>
<td>12.08</td>
<td>73</td>
<td>92.71</td>
<td>67,678.83</td>
</tr>
<tr>
<td>Barley</td>
<td>14.93</td>
<td>3590</td>
<td>107.87</td>
<td>387,253.30</td>
</tr>
<tr>
<td>Jwar</td>
<td>8.72</td>
<td>5432</td>
<td>105.04</td>
<td>570,557.28</td>
</tr>
<tr>
<td>Bajra</td>
<td>7.12</td>
<td>1912</td>
<td>99.01</td>
<td>189,306.12</td>
</tr>
</tbody>
</table>

\[ \sum = 23579 \quad \sum = 2546361.40 \]

Productivity index for cereal crops for the block:

\[
P. I. = \frac{\sum \text{Col. 6}}{\sum \text{Col. 4}}
\]

\[
P. I. = \frac{2546361.40}{23579}
\]

\[
P. I. = 107.99
\]

Note: Cereal crops index for Ghatampur block = 107.99%
the crop yield in the block is multiplied by the area under the crop in that block and the product is listed in col. 6 of the table. By adding the products of col. 6 and dividing it by the sum total of col. 4, the average index is obtained which is the desired crop index of a block, using crop area as weight.

Agricultural productivity is a multidimensional concept, which includes technological advancement, effective management of available resources and organizational set up for the agricultural production. These factors in turn affect the relative productivity of any region. The variation in the level of agricultural productivity attracted attention of the researchers and planners, because the basic objective of agricultural planning in India is to attain the level of self sufficiency in all agricultural production. Therefore, for researchers it is important to measure the level of agricultural productivity on a micro level in different regions of the country and study as to how far the objective of agricultural planning for the production of cereals, pulses, oilseeds, cash crops and raw material for agro-based industries has been achieved. This type of study will no doubt help to increase all round agricultural production which will certainly cutdown the import level of agricultural produce.
The study area, 'lower Ganga-Yamuna Doab' is the most agriculturally important part of Uttar Pradesh, lies between the two master rivers Ganga and Yamuna. It is an integral part of Indo-Gangatic plain. This plain is made of alluvial deposits brought down by the Himalayan rivers. The area has a gentle rolling topography having a gradient of less than 1 foot per kilometer.

Cereals:

Cereals constitute the chief item in the diet for a large chunk of the population in the region because they are comparatively cheap source of calories. The importance of cereal crops are increasing day by day because of increasing need of the growing population of world in general and of the study region in particular. Increasing the cereal production is an important step in transforming the agriculture of the region in order to fulfill the food requirement of the growing population. The cereal crops do not fix atmospheric nitrogen for soil enrichment as pulses do, but the residues from the cereals return more organic matter to the soil than do the pulses.

The main cereal crops are wheat, rice, maize, barley, jwar and bajra. Among these, wheat, rice and bajra are the crops which are consumed in the region. These crops provide about 75 per cent of the required calories at a cheaper rate
as compared to other crops. The protein content of cereal crops ranges between 6 to 12 per cent. The protein content of wheat is 11.8 per cent, rice 7.5 per cent, maize 9.5 per cent, and barley 11 per cent. Beside protein these cereal crops contain fats, calcium and iron also. As far as calories are concerned per 100 grams of wheat contains 330 calories, rice 357 calories, maize 356 calories and barley 330 calories. But the mineral content of cereals are low. Rice has a small amount of calcium and a very small amount of iron content.

**Pulses:**

Pulses are the chief and cheap source of protein for the rural population of the region which could not afford meat in their diet. The protein of pulses is of relatively low quality because of the deficiency of the essential amino-acid methionina. However, pulses protein are rich in lysin and are good of supplementary value, to cereal diets. The lysin deficiency of cereals is supplemented by the rich lysin of pulses. Thus the biological value of cereals and pulses diet is satisfactory. Pulses are poor in minerals but are rich in vitamin 'B', especially thiamine and folic acid. Dry pulses do not contain vitamin 'C' in significant amount, but when they are germinated, significant amount of vitamin 'C' are produced. So sprouted pulses, especially

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sprouted green gram (Mung) and bengal gram become rich source of vitamin 'C'.

The rural masses of lower Ganga-Yamuna Doab are mostly vegetarian depending largely on cereals and pulses as their staple food which provides the main source of nutrition.

Oil Seeds:

Oil seeds contribute an important part in agricultural economy. Edible oil is extracted from these oil seeds which forms an essential part of human diet of masses in the region. Non edible oil are used in some industries such as soap, paint, lubricant greases and varnish industries etc. Mustard, linseed and til are the main oil seeds produced in the region of lower Ganga-Yamuna Doab. Like cereals and pulses, oil seeds are rich in protein content. Beside protein it also contain fats in large quantity which results the high caloric value of it. Almost all the oil seeds produced in the region are consumed locally. The protein content of oil seeds is of poor quality because it has deficiency of amino-acid methionine. Beside protein oil seeds are rich in vitamins B-complex.

Cash Crops:

As the agriculture advances, it turns towards commercialization. There is a growing interest in farmers to
produce market oriented crops which has high remunerative value. Sugarcane and potato are the important cash crops grown in the region. Potato is rich in starch content. It is first grade energy producer because it can produce energy quickly. Its caloric value is high. Minerals and vitamins are absent in potato. Sugarcane is another cash crop of the region. It contains carbohydrate in large quantity. Like starch, carbohydrate is also a first grade energy producer because it also produce energy very quickly. Sugar and jaggery is made of sugarcane, has a little amount of iron content in it.

All the above discussed crops of the lower Ganga-Yamuna Doab has low nutritive value as compared to the crops produced in highly developed countries. Considerable attempts have been made to increase agricultural productivity quantitatively but not qualitatively. In the present context it is essential to develop some ways and means by which the nutritive value of all the crops can be improved. Beside increasing agricultural productivity quantitatively if the nutritive value of all the crops is improved then only in the true sense agricultural productivity can be raised.

The productivity of different groups of crops i.e., cereals, pulses, oil seeds and cash crops for the year 1975-76
Productivity Regions —— Cereals:

Cereal crops acquire very important position in the agriculture of lower Ganga-Yamuna Doab. It occupies 1056687 hectares of cultivated land which accounts for 55 per cent of the total gross cropped area of the region. Among the cereals rice and wheat are the most important crops grown in the region, which together occupy 52 per cent of the total cropped area. Productivity regions of cereals are shown in figure 26 and the number of blocks in each category i.e., high, medium and low productivity with their productivity indicies are shown in table 37.

The table reveals that in the study region there are 14 blocks which falls under high productivity region having productivity indicies above 110. These blocks are Chaubypur, Amauli, Khajuha, Deomai, Malvan, Telyani, Bahuva, Bhitaura, Asother, Hathgaon, Airayan, Vijaypur, Dhata and Nevada. All these blocks lie in the central part of the region except Chaubypur and Nevada which lie in the north-west and south-east of the region. The blocks under high productivity of cereals cover the total cropped area of 370487 hectares, which is 34.4 per cent of the total cropped area of the region.
<table>
<thead>
<tr>
<th>Category</th>
<th>Cereals</th>
<th>Pulses</th>
<th>Oil seeds</th>
<th>Cash crops</th>
<th>Composit Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indices</td>
<td>No. of Blocks</td>
<td>Indices</td>
<td>No. of Blocks</td>
<td>Indices</td>
</tr>
<tr>
<td>High</td>
<td>Above 110</td>
<td>14</td>
<td>Above 120</td>
<td>11</td>
<td>Above 100</td>
</tr>
<tr>
<td>Medium</td>
<td>90 -110</td>
<td>17</td>
<td>90 - 120</td>
<td>15</td>
<td>80 - 100</td>
</tr>
<tr>
<td>Low</td>
<td>Below 90</td>
<td>10</td>
<td>Below 90</td>
<td>15</td>
<td>Below 80</td>
</tr>
</tbody>
</table>
LOWER GANGA-YAMUNA DOAB
PRODUCTIVITY REGIONS—CEREALS
1975–76

INDEX

HIGH  ABOVE 110
MEDIUM  90 – 110
LOW  BELOW 90

T A  TOWN AREA OF KANPUR

FIG. 26
Medium productivity region of cereals having productivity indices between 90 and 110 includes 17 blocks which are spread over eastern and western parts of the lower Ganga-Yamuna Doab. These blocks are Rajpur, Akbarpur, Sarvankhera, Rasulabad, Cheenjhak, Sandalpur, Bilhaur, Kakvan, Shivrajpur, Kalyanpur, Chail, Muratganj, Kaushambi, Manjhanpur, Sarsava, Kara and Sirathu. All these blocks together have 396952 hectares of cropped area under cereal crops, which accounts for 37.4 per cent of the total cropped area of the study region.

Low productivity region includes 10 blocks of lower Ganga-Yamuna Doab. These blocks are Ghatampur, Derapur, Sarsaul, Vidhnu, Patara, Bheetargaon, Amraudha, Malasa, Maitha and Hasva. All these blocks are lying in the western part of the region except Hasva which lies in the central part of the Doab. The productivity indices of these blocks remain below 90. The low productivity region covers an area of 289248 hectares which accounts for 27.2 per cent of the total cropped area of the lower Ganga-Yamuna Doab.

Productivity Regions —— Pulses:

Pulses are the next important crops after cereals. It has an area of 250448 hectares which accounts for 23.58 per cent of the gross cropped area of the lower Ganga-Yamuna
Doab. The high, medium and low productivity region of pulses are shown in figure 27. In the study area there are 11 blocks which fall under high productivity region with the productivity indices above 120. These blocks are Gheenjhak, Hathgaon, Airayan, Kara, Sirathu, Manjhanpur, Sarsava, Muratganj, Kaushambi, Nevada and Chail. All these blocks are lying in the eastern part of the study area except Gheenjhak, which is lying in the extreme west of the Doab. The high productivity region of pulses has an area of 214,896 hectares which accounts for 20.2 per cent of the total cultivated area of the region.

Medium productivity region of pulses includes 15 blocks having productivity indices between 90 and 120. These blocks are Amraudha, Malasa, Akbarpur, Sarvankhera, Chaubypur Kakvan, Kalyanpur, Amauli, Khajuha, Deomai, Malvan, Bahuva, Bhitaura, Asothar and Dhata. These blocks are scattered in three isolated patches which lie in north-western, western and central parts of the lower Ganga-Yamuna Doab. All the blocks under medium productivity of pulses have 408,379 hectares of cultivated area which is 38.5 per cent of the total cropped area under pulses of the region.

Low productivity region of pulses occupies 15 blocks of the study area. It has 438,784 hectares of land under
LOWER GANGA-YAMUNA DOAB
PRODUCTIVITY REGIONS - PULSES
1975-76

INDEX

HIGH
ABOVE 120

MEDIUM
90 - 120

LOW
BELOW 90

T.A. TOWN AREA OF KANPUR

FIG 27
pulses which accounts for 41.3 per cent of the total area under pulses in the study region. The productivity indices of this region is below 90. Low productivity region of pulses consists the blocks of Ghatampur, Patara, Bheetargaon, Rajpur, Maitha, Derapur, Rasulabad, Sandalpur, Bilhaur, Shivrajpur, Sarsaul, Vidhnu, Telyani, Hasva and Vijaypur. All these blocks are intermixed with medium productivity blocks in the western and central part of the lower Ganga-Yamuna Doab.

**Productivity Region — Oil seeds:**

Oil seeds are very important crops grown in the study area. The oil extracted from these crops are generally used in cooking food items. This cooking oil provides fats in a large quantity to the consumer. Oil seeds occupies 33146 hectares of cultivated area which is 3.12 per cent of the total cropped area of the region. The high, medium and low productivity region of oil seeds are shown in figure 28.

There are 11 blocks in the study area which have high oil seeds productivity in comparison to others. Its productivity indices ranges above 100. These blocks are Ghatampur, Patara, Amraudha, Malasa, Maitha, Derapur, Rasulabad, Gheenjhak, Sandalpur, Kalyanpur and Vidhnu. All these blocks lie in western part of the lower Ganga-Yamuna
Doab. This region of high productivity of oil seeds has an area of 12203 hectares under oil seeds which accounts for 36.8 per cent of the total cropped area of the study region.

Medium productivity region of oil seeds lies in the north west and central part of the lower Ganga-Yamuna Doab. Its productivity indices ranges from 80 to 100. The medium productivity region consists of 19 blocks. These blocks are Bheetargaon, Akbarpur, Sarvankhera, Bilhaur, Chaubypur, Kakvan, Shivrajpur, Sarsaul, Amauli, Deomai, Malasa, Telyani, Bahuva, Bhitaura, Hasva, Asothar, Hathgaon, Kara and Sirathu. All these blocks together have an area of 8952 hectares under oil seeds cultivation which accounts for 27 per cent of the total area under the crop in the study region.

Low productivity region of oil seeds having productivity indices below 80, includes the blocks of Rajpur, Khajuha, Airayan, Vijaypur, Dhata, Chail, Nevada, Muratganj, Kaushambi, Manjhanpur and Sarsava. All these blocks are lying in the eastern part of the lower Ganga-Yamuna Doab, except Rajpur and Khajuha which lie in the south-western and central parts of the study area respectively. All these 11 blocks together constitute 11991 hectares of cultivated land.
LOWER GANGA-YAMUNA DOAB
PRODUCTIVITY REGIONS - OILSEEDS
1975-76

INDEX
HIGH
ABOVE 100
MEDIUM
80 - 100
LOW
BELOW 80

TA TOWN AREA OF KANPUR

FIG. 28
under oil seeds which accounts for 36.2 per cent of the total area under these crops in the study region.

Productivity Regions —— Cash crops:

The cash crops of the area include potato and sugar-cane. These two crops occupy lowest average among the four groups of crops i.e., cereals, pulses, oil seeds and cash-crops. Cash crops occupy an area of 28645 hectares which accounts for only 2.69 per cent of the gross cropped area of lower Ganga-Yamuna Doab. The high, medium and low productivity region of cash crops are shown in figure 29.

High productivity region of cash crops is consists of 8 blocks. It has productivity indicies above 150. The blocks under this category are Maitha, Sarvankhera, Bilhaur, Kakvan, Chail, Nevada, Kara and Sirathu. All these blocks are scattered in four patches lying in the north-west and eastern part of the lower Ganga-Yamuna Doab. These blocks together comprise 4151 hectares of cultivated area under cash crops which accounts for 14.4 per cent of the total area under these crops in the region.

Medium productivity region is consists of 17 blocks. The productivity indicies of this region ranges between 100 and 150. It includes the blocks of Ghatampur, Patara,
Bheetargaon, Rajapur, Malasa, Akbarpur, Rasulabad, Gheenjhak, Sandalpur, Shivrajpur, Khajuha, Deomai, Dhata, Muratganj, Kaushambi, Manjhanpur, and Sarsava. All these blocks lie in eastern and western parts of the study area. This region has an area of 12,955 hectares under cash crops which accounts for 43.3 per cent of the total cultivated area under these crops in the study region.

Low productivity region of cash crops is consists of 16 blocks. It has productivity indices below 100. These blocks are Amraudha, Derapur, Chaubypur, Kalyanpur, Sarsaul, Vidhnu, Amauli, Malvan, Telyani, Bahuva, Bhitaura, Hasva, Asother, Hathgaon, Airayan and Vijaypur. All these blocks are scattered in north-western, south-western and central parts of the lower Ganga-Yamuna Doab. This region of low agricultural productivity of cash crops has an area of 11,539 hectares which accounts for 40.3 per cent of the total cultivated area under these crops in the study region.

**Productivity Region — Based on Composit Index:**

After calculating the composit index of agricultural productivity for each block, the over all picture of agricultural productivity is presented in figure 30. From this figure it can be seen that the high productivity region whose productivity indices are above 110 includes the blocks of Maitha, Sarvankhera, Gheenjhak, Bilhaur, Chail, Nevada,
LOWER GANGA-YAMUNA DOAB
PRODUCTIVITY REGIONS BASED ON COMPOSITE INDEX
1975-76

FIG. 30

INDEX

HIGH

ABOVE 110

90 - 110

LOW

BELOW 90

1. A. TOWN AREA OF KANPUR

KMS
Kaushambi, Kara and Sirathu. These blocks of high agricultural productivity lie in the eastern and western parts of the lower Ganga-Yamuna Doab. It covers an area of 212412 hectares which accounts for 20 per cent of the gross cropped area of the study region.

The blocks having medium productivity are scattered all over the study area intermixing with high and low productivity blocks. The productivity indicies of the region ranges between 90 and 110. It includes 22 blocks namely Bheetargaon, Malasa, Akbarpur, Rasulabad, Sandalpur, Kakvan, Shivrajpur, Amauli, Khajuha, Deomai, Malvan, Telyani, Bahuva, Bhitaure, Asother, Hathgaon, Airayan, Vijaypur, Dhata, Muratganj, Manjhanpur and Sarsava. All these blocks together cover an area of 562892 hectares which accounts for 53 per cent of the gross cropped area of the study region.

Low productivity region is comprising the remaining 10 blocks. These blocks are Ghatampur, Patara, Amraudha, Rajpur, Derapur, Chaubypur, Kalyanpur, Sarsaul, Vidhnu and Hasva. The productivity indicies of this region is below 90. All the blocks of low productivity lie in the western part of the study area intermixing with the blocks of high and medium productivity except Hasva which lies in the central part of the Doab surrounded by medium productivity region. The cultivated area of this region is 286756 hectares which accounts for 27 per cent of the gross cropped area of
lower Ganga-Yamuna Doab.

The agricultural productivity regions of different groups of crops i.e., cereals, pulses, oil seeds and cash crops for the year 1985-86 has been worked out in the following pages.

Productivity Regions — Cereals:

Cereals are the most important crops grown in the lower Ganga-Yamuna Doab. They occupy 1114324 hectares of cultivated land which accounts for 58 per cent of the gross cultivable area in the lower Doab. Among cereals rice and wheat are the most dominant crops which alone acquire 76.17 per cent of the total cultivated area under cereals. The productivity regions of cereals are shown in figure 31 and the number of blocks in each category i.e., high, medium and low productivity with their productivity indices are shown in table 38.

From the table it can be seen that there are 18 blocks which fall under the category of high productivity region of cereals. This category has productivity indices above 110. The blocks under this category are Patara, Rajpur, Malasa, Akbarpur, Maitha, Rasulabad, Gheenjhak, Chaubypur, Kakvan, Shivrajpur, Vidhnu, Amauli, Malvan, Telyani, Bahuva, Asothar, Airayah, and Vijaypur. All these blocks together constitute an area of 448850 hectares under cereals which
<table>
<thead>
<tr>
<th>Category</th>
<th>Cereals Indices</th>
<th>No. of Blocks</th>
<th>Pulses Indices</th>
<th>No. of Blocks</th>
<th>Oil seeds Indices</th>
<th>No. of Blocks</th>
<th>Cash crops Indices</th>
<th>No. of Blocks</th>
<th>Composit Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Above 110</td>
<td>18</td>
<td>Above 120</td>
<td>14</td>
<td>Above 100</td>
<td>14</td>
<td>Above 150</td>
<td>9</td>
<td>Above 110</td>
</tr>
<tr>
<td>Medium</td>
<td>90 - 110</td>
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<td>15</td>
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<td>17</td>
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<tr>
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<td>Below 90</td>
<td>12</td>
<td>Below 80</td>
<td>12</td>
<td>Below 100</td>
<td>15</td>
<td>Below 90</td>
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</table>
accounts for 40.28 per cent of the total area under cereals in the study area. These blocks under high productivity of cereals are spread in western, north-western and central part of the lower Ganga-Yamuna Doab.

Medium productivity region of cereals having productivity indices between 90 and 110, cover 19 blocks. These blocks are Ghatampur, Bheetargaon, Amraudha, Sarvankhera, Derapur, Sandalpur, Kalyanpur, Sarsaul, Khajuha, Deomai, Bhitauna, Hasva, Hathgaon, Dhata, Chail, Nevada, Kaushambi, Sarsava and Sirathu. All these blocks together have an area of 579,448 hectares under cereals which accounts for 52 per cent of the total area under cereals in the study region. These blocks are interspread with high and low productivity blocks in the whole of the study area.

Low productivity region of cereals having productivity indices below 90 occupies only 4 blocks. These blocks are Bilhaur, Muratganj, Manjhanpur and Kara. All these blocks together have 86,026 hectares of area under cereals which accounts for 7.72 per cent of the total area under cereals in the study region. Out of these four blocks, three are lying in the north-eastern part, while fourth block is lying in the north-western part of the Doab.
Productivity Regions — Pulses:

Pulses are the second important group of crops grown in the region. It occupies 235402 hectares of cultivated area of the Doab which accounts for 16.5 per cent of the gross cropped area of the region. The productivity region of pulses are shown in figure 32 and the number of blocks under each category with their indicies number are shown in table 38.

The high productivity region of pulses constitute 14 blocks. This region has productivity indicies above 120. These blocks are Gheenjhak, Deomai, Hathgaon, Airayan, Vijai-pur, Dhata, Chail, Nevada, Muratganj, Kaushambi, Manjhanpur, Sarsava, Kara and Sirathu. All these blocks are concentrated in the eastern part of the lower Ganga-Yamuna Doab, except Gheenjhak and Deomai which lie in the western and central parts of the region respectively. Total area under high productivity region of pulses has been calculated as 69494 hectares which accounts for 29.5 per cent of the total area under pulses in the study region.

Medium productivity region includes 15 blocks having productivity indicies between 90 and 120. These blocks are Amraudha, Rajapur, Malasa, Akbarpur, Sarvenkhera, Chaubypur, Kakvan, Shivrajpur, Amauli, Khajuha, Malvan, Telyani, Bahuva, Bhitaura, and Hasva. All these blocks together have 95356
hectares of area under pulses which accounts for 40.5 per cent of the total area under pulses in the Doab. The blocks under this category are spread in three separate units lying in north-western, western to south western and central parts of the study area. These three units of medium productivity are separated from each other by low productivity region.

Low productivity region of pulses constitute 12 blocks having productivity indices below 90. These blocks are Ghatampur, Patara, Bheetargaon, Maitha, Derapur, Rasulabad, Sandalpur, Bilhaur, Kalyanpur, Sarsaul, Vidhnu, and Asothar. All these blocks together have 70552 hectares of land under pulses which accounts for 30 per cent of the total cultivated area under pulses in the study region. These blocks of low agricultural productivity are scattered in the western part, except Asothar which lies in the south-central part of lower Ganga-Yamuna Doab.

Productivity Regions — Oil seeds:

Oil seeds are the third important group of crops grown in the region. It occupies 47479 hectares of land which accounts for 6.16 per cent of the gross cropped area of the lower Ganga-Yamuna Doab. The productivity region of oil seeds are shown in figure 33 and the number of blocks under high, medium and low categories of agricultural productivity with their indices number are shown in table 38.
High productivity region of oil seeds comprises 14 blocks which are having productivity indices above 100. These blocks are Deomai, Malvan, Telyani, Bahuva, Bhitaura, Hasva, Asother, Chail, Nevada, Muratganj, Kausambi, Manjhanpur, Kara and Sirathu. All these blocks have an area of 5165 hectares under oil seeds which accounts for 10.88 per cent of the total area under the oil seeds in lower Ganga-Yamuna Doab. Out of 14 blocks under this category, 7 blocks lie in the eastern and 7 blocks in the central part of the Doab. These two units of high productivity are separated by low productivity region.

Medium productivity region of oil seeds occupies 15 blocks having productivity indices between 80 and 100. These blocks are Ghatampur, Patara, Bheetargaon, Amraudha, Malasa, Maitha, Sarvankhera, Derapur, Rasulabad, Gheenjhak, Bilhaur, Chaubypur, Kakvan, Shivrajpur, and Sarsava. All these blocks together have 28294 hectares of area under oil seeds which accounts for 59.60 per cent of the total area under these crops in lower Ganga-Yamuna Doab. All these blocks of high productivity are lying in the western part except Sarsava block which is lying in the south-eastern part of the study area.

Low productivity region of oil seeds comprises of 12 blocks having productivity indices below 80. These blocks are Rajpur, Akbarpur, Sandalpur, Kalyanpur, Sarsaul,
Vidhnu, Amauli, Khajuha, Hathgaon, Airayan, Vijaypur, and Dhata. All these blocks together have 14020 hectares of area under oil seeds which accounts for 29.52 per cent of the total area under this group of crops in the lower Ganga-Yamuna Doab. The blocks of low productivity of oil seeds are spread all over the study area intermixing with high and medium productivity blocks.

Productivity Regions —— Cash Crops:

Cash crops are the fourth and last important group of crops grown in the region. It occupies 32024 hectares of land which accounts for 4.15 per cent of the gross cropped area of the lower Ganga-Yamuna Doab. The productivity regions of cash crops are shown in figure 34 and the number of blocks under high, medium and low productivity with their indices number are shown in table 38.

High productivity region of cash crops consists of 9 blocks having productivity indices above 150. These blocks are Maitha, Sarvankhera, Bilhaur, Kakvan, Chail, Nevada, Sarsava, Kara and Sirathu. These blocks together have an area of 7933 hectares under cash crops which accounts for 24.77 per cent of the total area under this crop in lower Ganga-Yamuna Doab. These blocks of high productivity lie in the north-western and eastern parts of the study area.
Medium productivity region occupies 17 blocks having productivity indices between 100 and 150. These blocks are Ghatampur, Patara, Bheetargaon, Rajpur, Malasa, Akbarpur, Rasulabad, Gheenjhak, Sandalpur, Shivrajpur, Khajuha, Deomai, Bhitauna, Hasva, Asother, Hathgaon and Airayan. All these blocks together have an area of 8308 hectares under cash crops which accounts for 25.95 per cent of the total area under these crops in the lower Ganga-Yamuna Doab. All the 17 blocks of medium productivity of cash crops are spread in the whole Doab, except eastern part of it, intermixing with the blocks of low agricultural productivity.

Low productivity region of cash crops is comprising of 15 blocks having productivity indices below 100. These blocks are Amraudha, Derapur, Chaubypur, Kalyanpur, Sarsaul, Vidhnu, Amauli, Malvan, Telyani, Bahuva, Vijaypur, Dhata, Muratganj, Kaushambi and Manjhanpur. All these blocks together have 15783 hectares of land under cash crops which account for 49.28 per cent of the total area under cash crops in the study area. All these 15 blocks of low productivity are interspread in whole Doab with high and medium productivity blocks.

Productivity Regions — Based on Composit Index:

After calculating the composit index of agricultural productivity for each block, the over all picture of agricultural productivity is presented in figure 35 and the
number of blocks under high, medium and low productivity with their indices number are shown in the table 38.

Area under high productivity of agriculture having productivity indicies above 110, lies in western and eastern parts of the lower Ganga-Yamuna Doab, except Deomai block which lies in the central part of it. In all high productivity region comprises 11 blocks namely Maitha, Sarvankhera, Gheenjhak, Kakvan, Deomai, Airayan, Chail, Nevada, Sarsava, Kara and Sirathu. All these blocks together have area of 556972 hectares which accounts for 39.02 per cent of the total gross cropped area of the lower Ganga-Yamuna Doab.

Medium productivity region occupies 26 blocks having productivity indicies between 90 and 110. These blocks are Ghatampur, Patara, Bheetargaon, Amraudha, Rajpur, Malasa, Akbarpur, Derapur, Rasulabad, Bilhaur, Chaubypur, Shivrajpur, Amauli, Khajuha, Malvan, Telyani, Bahuva, Bhitaura, Hasva, Asothar, Hathgaon, Vijaypur, Dhata, Muratganj, Kaushambi and Manjhanpur. All these blocks together have an area of 776459 hectares which accounts for 54.40 per cent of the total cropped area of the study region. The blocks under medium agricultural productivity are spread over the entire Doab from west to east, intermixed with high and low productivity blocks.
The area under low agricultural productivity consists only 4 blocks having productivity indices below 90. These blocks are Sandalpur, Kalyanpur, Sarsaul and Vidhnu. These four blocks have an area of 93848 hectares, which accounts for 6.58 per cent of the total gross cropped area of the Doab. Out of these four blocks under low agricultural productivity, three lie in the north-west and one in the south-west of the lower Ganga-Yamuna Doab.

To make a comparative study of agricultural productivity for the year 1975-76 and 1985-86, it is essential to study the changes occurred in productivity at these two periods of time. Table 39 shows the changing pattern of agricultural productivity of the study region from 1975-76 to 1985-86. In this table the change in the number of blocks under different productivity regions and the acreage change under different categories of productivity regions has been clearly shown.

From table 39 it can be seen that in the year 1985-86 the high productivity region of cereal crops is increased by four blocks or an additional area of 78363 hectares have been added to high productivity region of cereals in 1985-86. Medium productivity region has gained an area of 182496 hectares from 1975-76. While the low productivity region of cereals has lost an area of 203222
<table>
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<th>Oil seeds</th>
<th>Cash crops</th>
<th>Over all Agricultural Productivity</th>
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<td>Change in Area in Hect.</td>
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</table>
hectares during this period. Thus from the table it can be revealed that from the year 1975-76 to 1985-86 the areal extent of high productivity region of cereals has been increased by 21 per cent and medium productivity region 47 per cent of the area under this category of cereals in 1975-76. While the areal extent of low productivity region has decreased by 70 per cent of the area under low productivity of cereals in 1975-76. This gives a clear indication that the area of low productivity of cereals of 1975-76 has transformed into the areas of medium and high productivity in 1985-86.

Pulses are the next important group of crops grown in the lower Ganga-Yamuna Doab. Table 39 reveals that from 1975-76 to 1985-86 the high productivity region of pulses has increased by three blocks, whereas the total cultivated area of pulses under this category has decreased by 145402 hectares which accounts for 67 per cent of the area under high productivity region of pulses in 1975-76. Medium productivity region has lost an area of 313023 hectares which accounts for 76.50 per cent of the area of pulses under this category in 1975-76. The area of low productivity region of pulses has declined by 368232 hectares which accounts for 84 per cent of the area of pulses under this category in 1975-76. Thus it can be said that under all the three categories of agricultural productivity, pulses
suffer a great loss in areal extent which is unfortunately not a good sign of agricultural transformation of the region. The downfall trend in acreage and production of pulses under each category of productivity region clearly shows that farmers have adjusted their crop acreage in accordance with the shift in techno-economic conditions.

The continued downward trend of acreage and production and low yield of pulses during the study period shows that it has not received the benefits of modern researches as compared to cereals. The use of indigenous seeds, lack of financial resources and non-use of chemical fertilizers and attack of many insects, pests which damage the leaf, stem and pods have gone to make the production static or even to its decline.

In the lower Ganga-Yamuna Doab it is seen that the adoption of improved pulses technology is almost nil and the farmers are growing pulses traditionally as a mixed crop. By field observation it is found that with the introduction of high yielding varieties of seeds of cereals, the area which was previously occupied by pulses now transformed to cereals cultivation, and thus the pulses have been neglected so much so that in the area of assured irrigation they are being pushed out of cultivation.
The productivity of pulses can be increased either by bringing more area under cultivation of pulses or by increasing their production per unit area and per unit time through better management.

In the study region it has been found that pulses of summer season generally do not suffer from diseases and pests. Arhar T-21 can be introduced on a large scale in the area of assured irrigation of lower Ganga-Yamuna Doab. National demonstration conducted in Kanpur has shown that a farm can harvest 2000 - 2500 kg of Arhar by sowing T-21 per hectare before wheat. It has been also observed on field that the average yield of moong and urd in Zaid season is better than that of Kharif season in irrigated areas, because of low susceptibility of disease and pests. But the cost on irrigation is so high that the net return per hectare is poor. Therefore, such varieties like T-21 and T-44 need to be developed which can thrive well with less irrigation and give higher yield and net return.  

Oil seeds are the third important group of crops grown in lower Ganga-Yamuna Doab. The areal extent of

high productivity region of oil seeds is decreased by 7038 hectares from 1975-76 to 1985-86, which accounts for a little more than 57 per cent of the area of oil seeds under this category in 1975-76. Medium productivity region is increased by 19342 hectares of area which accounts for 216 per cent of the area of oil seeds under medium category of productivity in 1975-76. The areal extent of low productivity region is increased by 2029 hectares which accounts for 17 per cent of the area under this category of oil seeds in 1975-76. Thus from table, it can be seen that from 1975-76 to 1985-86, the area of high productivity of oil seeds is declined whereas the area of medium and low productivity of oil seeds is increased.

Cash crops are the fourth important group of crops grown in the study area. The high productivity region of cash crops is increased by 3784 hectares which accounts for a little more than 91 per cent of the total area of cash crops under high productivity region in 1975-76. Medium productivity region of cash crops loses 4647 hectares of area from 1975-76 to 1985-86 which accounts for a little loss than 36 per cent of the area of cash crops under this category in 1975-76. Low productivity region of cash crops is gained by 2029 hectares of land from 1975-76 to 1985-86, which accounts for 17.50 per cent of the area of cash crops
under this category in 1975-76. Thus by table 39 we can see that in case of cash crops, areal extent of medium productivity region is decreased, while that of high and low productivity regions is increased.

At last comes the productivity regions based on composit index of agricultural productivity. Here in this case high productivity region is increased by 344560 hectares of area which accounts for 162 per cent of the gross cropped area under high productivity region in 1975-76. Medium productivity region is increased by 213567 hectares of area which is about 38 per cent of the gross cropped area of study region under this category in 1975-76. Low productivity region of 1985-86 is decreased by 192908 hectares which accounts for 67 per cent of the gross cropped area of lower Ganga-Yamuna Doab under this category in 1975-76. Thus it can be said that the areal extent of high and medium productivity regions are increased, whereas the areal extent of low productivity region is decreased. It means that 67 per cent area of low productivity region of 1975-76 has become the area of medium and high productivity region, giving a rising trend of overall agricultural productivity of the lower Ganga-Yamuna Doab.
CHAPTER VIII

PATTERNS OF CROPLAND USE AND TOTAL VOLUME OF CHANGE
IN THE LOWER GANCA-YAMUNA DOAB

Review of changes of cropping pattern gauges the shifts in area under different crops over a period of time. The heterogeneity and possibility of crops substitution are the two important characteristics of agricultural land which deserve special mention in studies pertaining to cropping pattern changes. In the region of lower Ganga-Yamuna Doab heterogeneity of land arises due to difference in availability of irrigation among different blocks of the region. Impact of changes in technological, institutional and socio-economic factors can be felt only when the existing cropping pattern undergoes a change. Generally, the cultivators have a tendency to stick to a stable cropping pattern under any given agro-climatic region and they do not shift much from this position to the extent dictated by price factors in adjusting acreage allocation. Breakthrough in farm technology makes a room for new production opportunities which do change the cropping pattern but with some time lag. Newer production opportunities became possible by new technology such as use of high yielding varieties of seeds along with chemical fertilizers, pesticides, insecticides and assured irrigation.

The cropping pattern of individual or group of farmers within each block determine the aggregate cropping pattern.
The cropping pattern of lower Ganga-Yamuna Doab is typical of an underdeveloped agricultural economy in which most of cultivated area is devoted to subsistent crops and the immediate market, while the cash crops receive only negligible percentage of the average farm.¹

The farmers respond to changes in input costs, output prices and crop yield in their acreage decisions but they are reluctant to make change in the cropping pattern on a large scale. Lack of sufficient credit facilities, ignorance and uncertain future prospects restrain the farmers from undertaking any significant change in their area allocation. The slower rate of adoption of high yielding varieties programme by small farmers in the study area is a sufficient proof of this pattern of behaviour. In the long run the changes in cropping pattern do occur. In the light of this hypothesis the study of change in cropping pattern of the lower Ganga-Yamuna Doab is undertaken.

The relative position of strength among the crops of the lower Ganga-Yamuna Doab can be assessed by ranking them in each block in order of percentage of the total harvested cropland occupied by each crop. The crops occupying first second and third rank have been mapped for each block for the year 1975-76 and 1985-86, and the resulting patterns of distribution which emerges has been shown in figure 36 to 41.

First Ranking Crops (1975-76):

Figure 36 shows the distributional pattern of the crops that ranked first in percentage of the total harvested cropland in the year 1975-76. It can be seen from this figure that wheat holds first rank in twenty four out of forty one blocks of the region. It roughly occupies 59 percent of area of region. Out of these twenty four blocks, seventeen lie in the Kanpur district, three in Fatehpur district and four in Allahabad district. These blocks are Bilhaur, Shivrajpur, Rasulabad, Gheenjhak, Saudalpur, Derapur, Maitha, Chaubypur, Akbarpur, Malasa, Amraudha, Kalyanpur, Sarvankhera, Bidhnu, Patara, Sarsol and Bhitargaon which lie in Kanpur district. Blocks Deomai, Khajuha and Malvan lie in Fatehpur district and the blocks Chail, Nevada, Muratganj and Kera lie in Allahabad district. Wheat as a first ranking crop is mostly concentrated in Western and Central parts of the Doab. Another patch of wheat is found in the extreme eastern part of the Doab. These two areas of wheat concentration are separated by the areas of paddy and gram.

Second most important crop which occupies first rank in eleven blocks of the Doab in paddy. Its major area of concentration is located in the lower parts of Fatehpur and upper parts of Allahabad district. The blocks which are having paddy as a first ranking crop are Kakvan, Telyani,
Bahuva, Bhitaura, Hasva, Hathgaon, Airyan, Dhata, Koshambi, Manjhanpur and Sirathu. All these blocks together have 27 per cent area of the region. Almost all the blocks form a contiguous patch except block Kakvan which lies in the north-western corner of the Doab.

The third important crop which ranked first in six blocks of the Doab is gram. It occupies 14 per cent area of the Doab. The blocks having gram as a first ranking crop lie along the bank of Yamuna river in four different patches, separated by the area of wheat and paddy. The blocks having gram as first ranking crop include Rajpur, Ghatampur, Amoli, Asothar, Vijaypur and Sarsava.

Second Ranking Crops:

Figure 37 shows the distributional pattern of second ranking crops of lower Ganga-Yamuna Doab. From the figure it can be seen that paddy holds second position in fifteen blocks. These blocks are Rasulabad, Shivrajpur, Maitha, Sarvenkhera, Kalyanpur, Bidhnu, Sarsol, Bhitargaon, Deomai, Malvan, Asothar, Vijaypur, Kara, Muratganj and Chail. The area of paddy as a second ranking crop is widely spread throughout the study region in four isolated patches separated by the areas of gram and wheat.

Wheat is the other important crops which rank second in twelve blocks of the study area. These blocks are Ghatampur,
Rajpur, Kakvan, Amoli, Tilyani, Bahuva, Bhitaura, Hathgaon, Airayan, Dhata, Manjhanpur and Sarsava. All the blocks having wheat as a second ranking crop lie in eastern and central parts of the Doab, except two blocks of Kakvan and Rajpur which lie in the extreme west of the study region. Different patches of wheat are interspread with the areas of gram and paddy.

Gram is the third important crop which ranks second in eleven blocks of the study region. The blocks having gram as a second ranking crop are Patara, Malasa, Amraudha, Akbarpur, Derapur, Sandalpur, Khajuha, Hasva, Nevada, Koshambi and Sirathu. These blocks are concentrated in south-western, central and eastern parts of the region.

Maize is the fourth crop of the region which ranks second in two blocks of the study area. These two blocks are Chaubypur and Bilhaur. These blocks lie in contiguity to the north-western part of the Doab. The area of maize is surrounded by the areas of paddy, gram and wheat.

Arhar is the fifth crop of the study region which ranks second in only one block of the Lower Ganga-Yamuna Doab. This block is Gheenjhak which lies in the extreme west of the region and is surrounded by the areas of gram and paddy.

**Third Ranking Crops:**

From figure 38 it emerges that maize, paddy, gram, jwar, bajra, barley, wheat and arhar are the third ranking crops of
the lower Ganga-Yamuna Doab for the year 1975-76. Among these crops maize hold third rank in seven out of fortyone blocks of the study region. These blocks are Maitha, Sarvenkhera, Rasulabad, Kakvan, Shivrajpur, Kalyanpur and Airayan. The concentration of these blocks occurs in the western part of the Doab except block Airayan, which lies in the north-eastern part of the Doab. The patches of maize growing blocks are interspread with the areas of paddy gram and wheat.

Next third ranking crop is paddy. It occupies seven blocks of the study area. These blocks are Patera, Akbarpur, Derapur, Gheenjhak, Bilhaur, Khajuha and Nevada. All these blocks are spreadout in north-western western and central parts of the lower Ganga-Yamuna Doab except the block Nevada, which lies in south-eastern part of the study region, just before the confluence of the two great rivers.

Gram is the most important third ranking crop grown in the lower Ganga-Yamuna Doab. It occupies ten blocks of the region. These blocks are Bhitargaon, Chaubypur, Deomai, Malvan, Tilyani, Bahuva, Bhitauna, Hathgaon, Dhata and Kara. All these blocks lie in the central part of the lower Doab in contiguity except block Chaubypur which lies in north-west and blocks Dhata and Kara which lie in the eastern part of the region under study.
Jwar being another third ranking crop of the region occupies four blocks. These blocks are Ghatampur, Sarsol, Bidhnu and Amoli. The two blocks Sarsol and Bidhnu lie on the eastern margin of Kanpur district along the bank of river Ganga. While among the remaining two blocks, one lies on eastern margin of Kanpur district and the other on the western margin of Fatehpur district along the bank of river Yamuna.

Next third ranking crop of the study area is bajra. It occupies five blocks of the lower Ganga-Yamuna Doab. These five blocks are Rajpur, Malasa, Sandalpur, Chail and Sarsava. All these blocks lie in three different patches in the Doab. Block Sandalpur, Rajpur and Malasa lie in the south-west of the Doab. Block Chail lies in the eastern most part of the Doab and block Sarsava lies in the south-east of the Doab. The first three blocks fall in the district of Kanpur and the remaining two fall in the district of Allahabad.

Wheat is another crop which ranked third in the study region. It occupies four blocks of the lower Ganga-Yamuna Doab. These blocks are Hasva, Asothar, Vijaypur and Sirathu. All these blocks are spread in two different patches. Blocks Hasva, Asothar and Vijaypur lie in the south-central part while block Sirathu lies in north-eastern part of the Doab. These two patches of wheat as a third ranking crop are interspread with the areas of gram and maize.
Next important crop of lower Ganga-Yamuna Doab is barley which ranked third in three blocks of the region. These three blocks are Muratganj, Koshambi and Hanjhanpur. All these three blocks form a single patch of the crop in the eastern part of the Doab and is extended from north to south i.e., from the bank of river Ganga to the bank of river Yamuna.

Arhar is the least important crop of the study area which ranks third in only one block of the region. This block is Amraudha, which is lying in the south-west of the lower Ganga-Yamuna Doab along the northern bank of river Yamuna in Kanpur district.

After a gap of one decade in 1985-86, the cropping patterns of lower Ganga-Yamuna Doab have been changed considerably.

**First Ranking Crops (1985-86):**

Figure 39 shows the distributional pattern of the crops that ranks first in lower Ganga-Yamuna Doab in the year 1985-86. On comparing the maps of first ranking crops of 1975-76 and 1985-86, it can be seen that in 1975-76 there were three first ranking crops in the Doab and i.e., wheat, paddy and gram. While in the year 1985-86, gram disappears from the scene of first ranking crops leaving behind only wheat and paddy.
FIG. 39

LOWER GANGA—YAMUNA DOAB
FIRST RANKING CROPS
1985—86

INDEX
WHEAT
RICE

1. A. TOWN AREA OF KANPUR

10 20 30 Kms.
Among the crops grown in lower Ganga-Yamuna Doab in 1985-86, wheat is the foremost important crop. It occupies thirty four blocks of the study region as compared to 1975-76 where this crop occupied only twenty four blocks. The blocks having wheat as a first ranking crop are Ghatampur, Fatara, Bhitargaon, Rahpur, Malasa, Amraudha, Akbarpur, Maitha, Sarvenkhera, Derapur, Rasulabad, Gheenjhak, Sandalpur, Bilhaur Kakvan, Shivrajpur, Kalyanpur, Sarsol, Bidhnu, Amoli, Khajuha, Deomai, Malvan, Tilyani, Bahuva, Hasva, Vijaypur, Dhata, Chail, Nevada, Muratganj, Sarsava and Sirathu. All these thirty four blocks having wheat as a first ranking crop are spread throughout the study area.

Second first ranking crop grown in the Doab is paddy. It occupies only the remaining seven blocks of the study area. These blocks are Bhitaura, Asothar, Hathgaon, Airayan, Koshambi, Manjhanpur and Kara. All these blocks are lying along the banks of the master rivers in the eastern part of the lower Doab.

Second Ranking Crops:

With the increase of assured irrigation facilities the areal expansion of paddy as second ranking crop becomes possible which is shown in figure 40. In the year 1975-76 there were only fifteen blocks having paddy as a second ranking
crop. But in 1985-86 this area has been spread over twenty nine blocks which is nearly double the area of 1975-76. These twenty nine blocks are Patara, Bhitargaon, Amraudha, Akbarpur, Maitha, Sarvankhera, Derapur, Rasulabad, Gheenjhak, Sandalpur, Bilhaur, Kakvan, Shivrajpur, Kalyanpur, Sarsol, Bidhnu, Khajuha, Deomai, Malvan, Telyani, Bahuva, Hasva, Chail, Nevada, Muratganj, Manjhanpur, Sarsava, Kara and Sirathu. All these blocks are spread in whole of the study region from west to east in two units separated by the areas of wheat and gram.

Gram is the next important crop which is grown as a second ranking crop in six blocks of the lower Ganga-Yamuna Doab. In the year 1975-76 this crop occupied eleven blocks of the study region, but in 1985-86 its areal extent is limited to only six blocks which is nearly half of the area of 1975-76. The reason behind this is that with the increased irrigation facilities and modern technological inputs with High Yielding varieties seeds, the area under gram has been transformed to paddy. The blocks having gram as a second ranking crop are Ghatampur, Rajpur, Malasa, Amoli, Vijaypur, and Dhata. All these blocks are lying in eastern and western parts of the Doab along the river Yamuna.

After paddy and gram comes wheat which is another second ranking crop grown in five blocks of the lower Ganga-Yamuna
Doab. In 1975-76 wheat occupied twelve blocks but the area of wheat as a second ranking crop is reduced to about half in 1985-86. The area cut down from wheat has been shifted to pulses and vegetables cultivation. The blocks having wheat as a second ranking crop are Bhitaura, Asothar, Hathgaon, Airayan, and Koshambi. All these blocks are lying in central and eastern parts of the lower Doab along the rivers of Ganga and Yamuna.

The last crop which rank second in the lower Ganga-Yamuna Doab is maize. It occupies only one out of forty one blocks of the study area. In the year 1975-76 there were two blocks Chaubypur and Bilhaur under the cultivation of maize as a second ranking crop, but in 1985-86 block Bilhaur has been replaced by paddy cultivation leaving behind block Chaubypur for the cultivation of maize as a second ranking crop. Block Chaubypur is lying in the north-west of the study region in Kanpur district along the river Ganga.

Third Ranking Crops:

Figure 41 shows the distributional pattern of crops that ranked third in different blocks of the lower Ganga-Yamuna Doab. In the year 1975-76 there were in all eight crops grown in the lower Doab which were ranked third. But in 1985, after a gap of one decade, the number of crops have reduced to five. The remaining area of three crops, i.e.,
wheat, barley and arhar have been replaced by the cultivation of paddy, gram and bajra.

In the year 1985-86 gram is the most important third ranking crop of the Doab. It occupies twenty six out of forty one blocks of the study area. In 1975-76 only ten blocks were having this crop as a third ranking crop, but now its areal extent has been increased to twenty six blocks. These blocks are Patara, Bhitargaon, Amraudha, Akbarpur, Maitha, Sarvenkhera, Derapur, Rasulabad, Gheenjhak, Sandalpur, Kalyanpur, Sarsol, Khajuha, Deomai, Malvan, Tilyani, Bahuva, Hasva, Hathgáon, Airayan, Chail, Nevada, Koshambi, Sarsava, Kara and Sirathu. All the blocks having gram as a third ranking crop are spread over entire area of lower Ganga-Yamuna Doab from west to east in contiguity except four blocks of Chail, Nevada, Koshambi and Sarsava which are separated from the rest by the third ranking area of paddy, jwar and bajra cultivation. These four blocks are lying in the eastern most part of the lower Doab.

Next important crop is paddy which occupies second position among the third ranking crops of the lower Ganga-Yamuna Doab. It is grown in seven blocks of the Doab. These blocks are Rajpur, Malasa, Chaubypur, Amoli, Asothar, Vijaypur and Dhata. All these blocks are spread from west to east along the river Yamuna except block Chaubypur which is
lying in the north-west of the Doab along the river Ganga.

Jwar is the next crop which ranks third in the study area. It is grown in four blocks of the lower Ganga-Yamuna Doab. These blocks are Ghatampur, Bidhnu, Bhitaura and Manjhanpur. Block Ghatampur and Bidhnu are lying in the western part of the Doab, block Bhitaura in central part and block Manjhanpur in eastern part of the Doab.

After Jwar comes maize which is the next important third ranking crop of the lower Ganga-Yamuna Doab. It is grown in three blocks of the Doab. In the year 1975-76 there were seven blocks having maize as a third ranking crop. But in 1985-86 this area is confined to only three blocks and the remaining four blocks are occupied by the cultivation of third ranking gram.

Bajra is the least important crop of the Doab which ranks third in only one block of the study area. In the year 1975-76 there were five blocks which were having bajra as a third ranking crop but in 1985-86 its areal extent is confined to only one block i.e., block Muratganj which lies in the north-east of the study region along the river Ganga. In the remaining blocks bajra has been replaced by the cultivation of paddy and gram as the third ranking crops of the lower Ganga-Yamuna Doab.
The Total Volume of Change:

An attempt has been made to consider the total change in the acreage of the major crops as a group. These crops which have already been reviewed account for virtually all the harvested cropland within the area. A tallying of the percentage point of increase and decrease among these crops had, therefore, been taken to provide a reasonably accurate comparative measure of the total volume of change in the harvested cropland of the lower Ganga-Yamuna Doab.

The procedure which has been followed is rather simple. For each of the 41 blocks of the study area, abbreviated fractional expressions were worked out to show the size of the percentage point increase which occurred within each of the blocks in respect of each of the major crops. A crop identifying letter together with any existing point of increase has been placed in the numerator position of the fraction, and an identifying letter together with any existing decrease value has been placed in the denominator have been added up separately, the two sums then indicating a numerical fraction. On the basis of these computations, an index has been made available for indicating the total percentage of the harvested cropland affected in a given block as a result of changes in the relative strength of the major crops. Supposing that after the computation the fraction 16/10 for a particular block is obtained it would indicate that 16 per cent of the
harvested land increased under certain crops and 10 per cent decreased under other crops. The larger of the two digits has therefore been plotted on the map for that block, for the obvious reason that the percentage of total harvested cropland was involved in some form of land use change among the crops being summarized.

Having thus obtained a measure of the percentage of the harvested cropland involved in change among the major crops for every block, the information has been plotted in fig.42 & 43, the maps which provide a comparative view of the areas where the cropland use patterns have been relatively stable. It may be noted that the blocks where the shifts among the major crops affected has been less than 20 per cent of the harvested cropland, have been described as relatively stable, while those blocks where the magnitude of change is between 20 and 40 per cent of the total harvested cropland have been classified as unstable.

In examining figure 44 it would be noted that the condition of stability prevailed in a number of blocks lying in western and central parts of the region. Few blocks of eastern part of lower Ganga-Yamuna Doab also have stable conditions. The blocks having stable condition are Ghatampur, Bhitargaon, Rajpur, Malasa, Akbarpur, Rasulabad, Gheenjhak, Kakvan, Sarsol, Bidhnu, Amoli, Khajuha, Deomai, Malvan, Telyani, Baluva,
Among the major Doab crops the one identified made the largest gain percent of total harvested crop land.
LOWER GANGA-YAMUNA DOAB
LEADING DECREASE CROPS
1975-76 TO 1985-86

AMONG THE MAJOR DOAB CROPS THE ONE IDENTIFIED SUFFER THE LARGEST DECREASE PERCENT OF THE TOTAL HARVESTED CROPLAND.

INDEX

RICE
MAIZE
BAJRA
JOWAR
BARLEY
GRAM
ARHAR

TA TOWN AREA OF KANPUR
LOWER GANGA-YAMUNA DOAB
TOTAL VOLUME OF CHANGE
1975-76 TO 1985-86

PERCENT OF THE TOTAL HARVESTED CROP
LAND INVOLVED IN CHANGE AMONG THE
MAJOR DOAB CROPS.

INDEX
- 20 - 40 PER CENT
- BELOW 20 PER CENT

TA TOWN AREA OF KANPUR

FIG. 44
Bhitaura, Asother, Hathgaon, Dhata, Chail, Nevada, Kaushambi and Sarsava.

Area of dynamism lies in 17 out of 41 blocks of the region. These blocks are spread over eastern and western parts of the region which are Patara, Amraudha, Maitha, Sarvankhera, Derapur, Sandalpur, Chaubypur, Bilhaur, Shivrajpur, Kalyanpur, Hasva, Airayan, Vijaypur, Muratganj, Manjhanpur, Kara and Sirathu.

As a by-product of the summation analysis of change, two maps (figure 42 and 43) have been prepared; the first (figure 42) which by blocks identifies the crop which has made the largest percentage point increase in harvested cropland during the decade; and the second (figure 43) which shows the largest percentage point decrease in the same period. It will be seen from figure 42 that wheat and paddy are the two most important crops which made the largest percentage gain of total harvested cropland. In the eastern part of the region only wheat has made the largest percentage gain of the total harvested cropland except block Kaushambi where paddy shows largest percentage gain. While in the upper part of the study region, wheat and paddy both have made the largest gain in percentage of total harvested cropland.

From figure 43 it can be seen that there are seven crops namely maize, arhar, barley, gram, bajra, paddy and jwar
which suffer the largest decrease percentage of the total harvested cropland in different blocks of the lower Ganga-Yamuna Doab. Bajra suffered the largest decrease percentage of the total harvested cropland in 12 blocks spread throughout the entire lower Doab. Maize suffered in 9 blocks spread over western and central parts of the Doab. Barley suffered in six blocks out of which five blocks lie in eastern part and one lies in the western part of the study region. Gram suffered in five blocks of central part of the Doab. Paddy suffered in one block lying along the river Yamuna and jwar suffered the largest percentage decrease of the total harvested cropland in only one block lying at the confluence of river Ganga and Yamuna.

Figure 44 shows the trend of distributional pattern of dynamic and stable areas in the study region. From this figure it can be concluded that much of the stable areas lie in the middle and upper parts of the study region whereas the dynamic or sensitive areas are generally spread over eastern and western parts of lower Ganga-Yamuna Doab.
CHAPTER IX

IMPACT OF MODERN TECHNOLOGY IN TRANSFORMATION OF AGRICULTURE IN THE LOWER GANGLA-YAMUNA DOAB

The role of modern technology in agricultural transformation of lower Ganga-Yamuna Doab has been assessed in three ways. Firstly an attempt has been made to determine the role of the components of modern technology in agricultural transformation through the test of simple linear correlation during the period 1975-76 and 1985-86. Secondly, the precise role of various indicators of agricultural transformation is determined through factor analysis. Thirdly, the levels of agricultural transformation are determined in respect of changed cultivated area, changed agricultural production and changed agricultural productivity and the impact of the components of modern technology is also determined.

Test of Simple Linear Correlation:

The linear correlation coefficient between composit index of agricultural productivity and each of the thirteen independent variates, as set out in table 40 have been computed and tested with the assumption that linear relationship existed in all cases. The null hypothesis \( H_0 \) formulated is that the composit index of agricultural productivity of the blocks of lower Ganga-Yamuna Doab has no significant correlation with the variates selected. If the relationship
### Table - 40

**Variables of agricultural transformation**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>Tube-wells and pumping sets per 100 hectares of gross cropped area.</td>
</tr>
<tr>
<td>$X_2$</td>
<td>Iron plough per 100 hectares of gross cropped area.</td>
</tr>
<tr>
<td>$X_3$</td>
<td>Blade harrow and cultivators per 100 hectares of gross cropped area.</td>
</tr>
<tr>
<td>$X_4$</td>
<td>Tractor power per 1000 hectares of gross cropped area.</td>
</tr>
<tr>
<td>$X_5$</td>
<td>Fertilizer consumption in Kg. per hectare.</td>
</tr>
<tr>
<td>$X_6$</td>
<td>Cooperative banks.</td>
</tr>
<tr>
<td>$X_7$</td>
<td>Rural electrification as percentage.</td>
</tr>
<tr>
<td>$X_8$</td>
<td>Length of pukka road in kms. per 1000 hectares of net cultivated area.</td>
</tr>
<tr>
<td>$X_9$</td>
<td>Agricultural labourers and workers per 100 hectares of gross cropped area.</td>
</tr>
<tr>
<td>$X_{10}$</td>
<td>Literacy rate as percentage.</td>
</tr>
<tr>
<td>$X_{11}$</td>
<td>Irrigation intensity as percentage.</td>
</tr>
<tr>
<td>$X_{12}$</td>
<td>Size of land holding in hectares.</td>
</tr>
<tr>
<td>$X_{13}$</td>
<td>Percentage of area under High Yielding Varieties of seeds.</td>
</tr>
</tbody>
</table>
gives an index of variates well above the adopted level of significance, i.e., 5% level and 1% level, the null hypothesis is rejected and the valid inference seems to be obvious that these variates by all means are significant determinants of agricultural transformation in lower Ganga-Yamuna Doab.

From Table 41 it can be seen that in the year 1975-76 the composit index of agricultural productivity (Y) in the study region has significant degree of positive relationship

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level of confidence</th>
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<tr>
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<td>X_4</td>
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<tr>
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<tr>
<td>X_6</td>
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<tr>
<td>X_7</td>
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<td>X_8</td>
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</tr>
<tr>
<td>X_9</td>
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<td>X_10</td>
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<td>X_11</td>
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<td>X_12</td>
<td>-0.331</td>
</tr>
<tr>
<td>X_13</td>
<td>0.944</td>
</tr>
</tbody>
</table>
(1 per cent level of confidence) with tube-wells and pumping sets \(X_1\), iron plough \(X_2\), blade harrow and cultivators \(X_3\), tractor power \(X_4\), fertilizer consumption \(X_5\), rural electrification \(X_7\), irrigation intensity \(X_{11}\) and area under HYV seeds \(X_{13}\). The variable agricultural labourers \(X_9\) has high degree of positive relationship whereas size of land holding \(X_{12}\) has high degree of negative relationship. The remaining three variates i.e., co-operative banks \(X_6\), length of pukka road \(X_8\) and literacy rate \(X_{10}\) are far below the accepted level of probability.

During 1985-86, with few exceptions, the direction and degree of relationship vary (table 42). In this year the composit index of agricultural productivity \(Y\) in lower Ganga-Yamuna Doab has significant degree of positive correlation with the tube-wells and pumping sets \(X_1\), iron plough \(X_2\), blade harrow and cultivators \(X_3\), tractor power \(X_4\), fertilizer consumption \(X_5\), rural electrification \(X_7\), agricultural labourers and workers \(X_9\), irrigation intensity \(X_{11}\) and area under High Yielding Varieties of seeds \(X_{13}\). These variables are significant even at 1 per cent level of confidence. Literacy rate \(X_{10}\) and size of land holdings \(X_{12}\) are also significant at the same level but the degree of relationship is negative.
### Table - 42

**Simple linear correlation between dependent variable (Y) and independent variable (X₁₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋₋_-
dependent variable (Y) which is observed to be highly correlated with —

\[ X_2 \] iron plough (0.909)
\[ X_3 \] blade harrow and cultivators (0.919)
\[ X_4 \] tractor power (0.693)
\[ X_5 \] fertilizer consumption (0.973)
\[ X_7 \] rural electrification (0.956)
\[ X_{11} \] irrigation intensity (0.988)
\[ X_{13} \] area under HYV seeds (0.957)
\[ X_9 \] agricultural workers and labourers (0.434)
\[ X_{12} \] size of land holding (-0.436)

If iron plough \((X_2)\) is considered as dependent variable \((Y)\), its correlation with other independent variables are recorded where it is found that relatively high degree of relationships are registered with the variables \(X_3(0.939), X_4(0.666), X_5(0.893), X_7(0.947), X_{11}(0.921), X_{13}(0.948), X_9(0.466)\) and \(X_{12}(-0.449)\).

Taking blade harrow and cultivators \((X_3)\) as dependent variable \((Y)\), its correlation with independent variables are strong with \(X_4(0.919), X_2(0.939), X_4(0.781), X_5(0.864), X_7(0.981), X_{11}(0.915), X_{13}(0.958)\) and \(X_{12}(-0.413)\). Tractor power becoming dependent variable \((Y)\), has high degree of positive correlation with \(X_1(0.693), X_2(0.666), X_3(0.781), X_5(0.602), X_7(0.740), X_{11}(0.671)\) and \(X_{13}(0.686)\).
<table>
<thead>
<tr>
<th>( X_1 )</th>
<th>1.00000</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X_2 )</td>
<td>0.90964 1.00000</td>
</tr>
<tr>
<td>( X_3 )</td>
<td>0.91903 0.93916 1.00000</td>
</tr>
<tr>
<td>( X_4 )</td>
<td>0.69356 0.66620 0.78196 1.00000</td>
</tr>
<tr>
<td>( X_5 )</td>
<td>0.97368 0.89380 0.86482 0.60254 1.00000</td>
</tr>
<tr>
<td>( X_6 )</td>
<td>0.06422 0.14939 0.06605 0.18569 0.01228 1.00000</td>
</tr>
<tr>
<td>( X_7 )</td>
<td>0.95664 0.94738 0.98160 0.74099 0.91661 0.06210 1.00000</td>
</tr>
<tr>
<td>( X_8 )</td>
<td>0.02184 0.12194 0.06284 -0.06640 0.07569 0.24100 0.04838 1.00000</td>
</tr>
<tr>
<td>( X_9 )</td>
<td>0.43490 0.46635 0.38425 0.24002 0.44835 0.49283 0.39307 0.14978 1.00000</td>
</tr>
<tr>
<td>( X_{10} )</td>
<td>0.32636 0.33005 0.26935 0.18561 0.31936 0.17331 0.28682 0.14681 0.26188 1.00000</td>
</tr>
<tr>
<td>( X_{11} )</td>
<td>0.98879 0.92120 0.91516 0.67124 0.97799 0.05992 0.96079 0.02312 0.44794 0.31408 1.00000</td>
</tr>
<tr>
<td>( X_{12} )</td>
<td>-0.43617 -0.44910 -0.41335 -0.27227 -0.43410 -0.50746 -0.41759 -0.38167 -0.80589 -0.23539 -0.45024 1.00000</td>
</tr>
<tr>
<td>( X_{13} )</td>
<td>0.95731 0.94899 0.94899 0.95895 0.68690 0.93872 0.04436 0.98329 0.04225 0.42987 0.27041 0.97283 1.00000</td>
</tr>
</tbody>
</table>
Assuming X₅ fertilizer consumption as a dependent variable (Y), its correlation with independent variables are particularly strong with X₁(0.973), X₂(0.893), X₃(0.864), X₄(0.602), X₇(0.916), X₁₁(0.977), X₁₃(0.938), X₉(0.448) and X₁₂(-0.438). Co-operative banks as a dependent variable (Y), is not having any significant correlation with independent variables except X₉(0.492) and X₁₂(-0.507).

When (X₇) rural electrification is considered as a dependent variable (Y), then its correlation with independent variables are strong with X₁(0.956), X₂(0.947), X₃(0.981), X₄(0.740), X₅(0.916), X₁₁(0.960), X₁₃(0.984) and X₁₂(-0.417). Considering (X₉) length of pukka road as a dependent variable (Y), then its correlation with independent variables are very weak. None of the independent variables show correlation with dependent variable upto any level of significance. Only X₁₁ has a negative correlation of (-0.381).

When (X₉) agricultural labourers and workers are considered as dependent variable (Y), then its correlation with independent variables are strong with X₁₂(-0.805), X₁(0.434), X₂(0.466), X₅(0.448), X₆(0.492), X₁₁(0.447) and X₁₃(0.429). Assuming (X₁₀) literacy rate as a dependent variable (Y), then its correlation with independent variables are not strong. It has weak correlation with X₁(0.326), X₂(0.330), X₅(0.319) and X₁₁(0.314).
When \( X_{11} \) irrigation intensity is considered as dependent variable \( (Y) \), then its correlation with independent variables are strong with \( X_1(0.988), X_2(0.921), X_3(0.915), X_4(0.671), X_5(0.977), X_7(0.960), X_{13}(0.972), X_9(0.447) \) and \( X_{12}(-0.450) \).

Considering \( X_{12} \) size of land holding as a dependent variable \( (Y) \), then its correlation with independent variables are undermentioned: \( X_1(-0.436), X_2(-0.449), X_3(-0.413), X_5(-0.434), X_6(-0.507), X_7(-0.417), X_8(-0.381), X_9(-0.805), X_{11}(0.450), X_{13}(0.429) \). Thus it can be said that only \( X_{11} \) (irrigation intensity) and \( X_{13} \) (area under HYV seeds) have positive correlation with dependent variable \( (Y) \).

Lastly, assuming \( X_{13} \) area under HYV seeds as dependent variable \( (Y) \), then its correlation with independent variables are strong with \( X_1(0.957), X_2(0.948), X_3(0.958), X_4(0.686), X_5(0.938), X_7(0.983), X_{11}(0.972), X_9(0.429) \) and \( X_{12}(0.429) \).

The inter-relationship among independent variables for the year 1985-86 can be examined from table 44. The study reveals that the independent variable \( (X_1) \) becomes dependent variable \( (Y) \), and the correlation of this \( (Y) \) with independent variables are strong with \( X_2(0.781), X_3(0.859), X_4(0.938), X_5(0.876), X_6(0.770), X_{11}(0.777), X_{13}(0.859), X_9(0.411) \) and \( X_{12}(-0.403) \).
When \((X_2)\) iron plough is considered as dependent variable \((Y)\), then its correlation with independent variables are strong with \(X_1(0.781), X_3(0.955), X_4(0.722), X_5(0.878), X_7(0.962), X_9(0.517), X_{11}(0.820), X_{13}(0.872)\) and \(X_{12}(-0.499)\).

Assuming \((X_3)\) blade harrow and cultivators as dependent variable \((Y)\), then its correlation with independent variables are strong with \(X_1(0.859), X_2(0.955), X_4(0.807), X_5(0.882), X_7(0.917), X_{11}(0.756), X_{13}(0.846), X_9(0.471)\) and \(X_{12}(-0.429)\). Considering tractor power \((X_4)\) as dependent variable \((Y)\), then its correlation with independent variables are strong with \(X_1(0.938), X_2(0.722), X_3(0.807), X_5(0.713), X_7(0.706), X_{11}(0.628)\) and \(X_{13}(0.697)\).

When fertilizer consumption \((X_5)\) is considered as dependent variable \((Y)\), then its correlation with independent variables are strong with \(X_1(0.876), X_2(0.878), X_3(0.882), X_4(0.713), X_7(0.883), X_9(0.533), X_{11}(0.931), X_{13}(0.985)\) and \(X_{12}(-0.547)\). Assuming \((X_6)\) cooperative banks as a dependent variable \((Y)\), its correlation with independent variable is strong only with \(X_9(0.439)\). Other independent variables have weak correlation with \((Y)\).

Considering \((X_7)\) rural electrification as a dependent variable \((Y)\), its correlation with independent variables are strong with \(X_1(0.770), X_2(0.962), X_3(0.917), X_4(0.706), X_5(0.883), X_9(0.528), X_{11}(0.880), X_{13}(0.895)\) and \(X_{12}(-0.519)\).
<table>
<thead>
<tr>
<th></th>
<th>$X_1$</th>
<th>$X_2$</th>
<th>$X_3$</th>
<th>$X_4$</th>
<th>$X_5$</th>
<th>$X_6$</th>
<th>$X_7$</th>
<th>$X_8$</th>
<th>$X_9$</th>
<th>$X_{10}$</th>
<th>$X_{11}$</th>
<th>$X_{12}$</th>
<th>$X_{13}$</th>
</tr>
</thead>
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<td>$X_1$</td>
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<td></td>
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<tr>
<td>$X_3$</td>
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<td>$X_4$</td>
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<td>0.88289</td>
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<td>$X_7$</td>
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<td>0.96243</td>
<td>0.91769</td>
<td>0.70630</td>
<td>0.88338</td>
<td>0.14009</td>
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<td>$X_8$</td>
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<td>0.04441</td>
<td>-0.04771</td>
<td>0.09862</td>
<td>-0.08081</td>
<td>0.03604</td>
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<tr>
<td>$X_9$</td>
<td>0.41199</td>
<td>0.51776</td>
<td>0.47138</td>
<td>0.35699</td>
<td>0.53345</td>
<td>0.43991</td>
<td>0.52874</td>
<td>0.29630</td>
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<tr>
<td>$X_{10}$</td>
<td>-0.34481</td>
<td>-0.27903</td>
<td>-0.26332</td>
<td>-0.31572</td>
<td>-0.31705</td>
<td>-0.31493</td>
<td>-0.33769</td>
<td>0.14451</td>
<td>-0.63852</td>
<td>1.00000</td>
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<tr>
<td>$X_{11}$</td>
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<td>0.75667</td>
<td>0.62886</td>
<td>0.93152</td>
<td>0.18731</td>
<td>0.88038</td>
<td>0.07598</td>
<td>0.55262</td>
<td>-0.35897</td>
<td>1.00000</td>
<td></td>
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<tr>
<td>$X_{12}$</td>
<td>-0.40390</td>
<td>-0.49921</td>
<td>-0.42975</td>
<td>-0.34529</td>
<td>-0.54772</td>
<td>-0.39271</td>
<td>-0.51963</td>
<td>-0.35795</td>
<td>-0.87251</td>
<td>0.61045</td>
<td>-0.59325</td>
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<td>$X_{13}$</td>
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<td>0.87232</td>
<td>0.84658</td>
<td>0.69779</td>
<td>0.98585</td>
<td>0.23591</td>
<td>0.89540</td>
<td>0.07939</td>
<td>0.53744</td>
<td>-0.35251</td>
<td>0.97104</td>
<td>-0.55333</td>
<td>1.00000</td>
</tr>
</tbody>
</table>
When \((X_8)\) length of pukka road is considered as dependent variable \((Y)\), then its correlation with all the independent variables are very weak.

Assuming \((X_9)\) agricultural labourers and workers as dependent variable \((Y)\), then its correlation with independent variables are strong with \(X_2(0.517), X_5(0.533), X_7(0.528), X_{11}(0.552), X_{13}(0.537), X_3(0.471), X_6(0.439), X_{10}(-0.638)\) and \(X_{12}(-0.872)\). When \((X_{10})\) literacy rate is considered as dependent variable \((Y)\), then its correlation with independent variables are strong only with \(X_9(0.638)\) and \(X_{12}(0.610)\). Its correlation with other independent variables are weak and negative.

Considering \((X_{11})\) irrigation intensity as dependent variable \((Y)\), then its correlation with independent variables are strong with \(X_1(0.777), X_2(0.820), X_3(0.756), X_4(0.628), X_5(0.931), X_7(0.880), X_9(0.552), X_{13}(0.971)\) and \(X_{12}(-0.593)\).

Assuming \((X_{12})\) size of land holding as dependent variable \((Y)\), its correlation with independent variables are strong with \(X_{10}(0.610), X_5(-0.547), X_7(-0.519), X_9(-0.872), X_{11}(-0.593), X_{13}(-0.555), X_4(-0.403), X_2(-0.499)\) and \(X_3(-0.429)\). Considering \((X_{13})\) area under HYV seeds as dependent variable \((Y)\), its correlation with independent variables are strong with \(X_4(0.859), X_2(0.872), X_3(0.846), X_4(0.697), X_5(0.985), X_7(0.895), X_9(0.537), X_{11}(0.971)\) and \(X_{12}(-0.555)\).
Factor Analysis:

Factor analysis is considered to be a sound technique in determining the role of various factors of agricultural transformation of the study region, because by this technique the effects of independent variables on dependent one can be explained by a set of factors. The procedure of factor analysis attempts to assess the values of regression coefficients where the original variables are regressed on the factors. The coefficients of regression are termed as factor loadings. The factor loadings can be further processed by factor rotations which gives a set of new factor loadings for better explanation.

Earlier a number of social scientists have used factor analysis in their studies. Some important studies employing this statistical technique has been carried out by Kaiser (1958), Ahmad (1965), Harman (1967) and Morison (1967) etc.

In this study the thirteen variables which are given in Table 40 are considered to be suitable indices of agricultural transformation are collapsed into each other and are rotated further to perform a precise and new variate of agricultural

2. Ahmad, Q., Indian Cities: Characteristics and Correlates, University of Chicago, Research paper No. 102, 1965.
transformation in the lower Ganga-Yamuna Doab for two separate years 1975-76 and 1985-86. These calculations have been done through Factor Analysis Package Programme on Computer VAX-11-System.

The factor analysis for the year 1975-76 shows that 76.79 per cent of the total variance is explained by two groups of factors (table 45). Factor $F_1$ which explains 62.03 per cent of the total variance is strongly loaded on —

- $X_1$ tube-wells and pumping sets (0.95)
- $X_2$ iron plough (0.92)
- $X_3$ blade harrow and cultivators (0.95)
- $X_4$ tractor power (0.74)
- $X_5$ fertilizer consumption (0.93)
- $X_7$ rural electrification (0.98)
- $X_{11}$ irrigation intensity (0.96)
- $X_{13}$ area under HYV seeds (0.97)

Factor $F_2$ accounts for 14.76 per cent of the total variance explained. It is strongly loaded on about thirty-three per cent of the variables. They are —

- $X_6$ co-operative banks (0.74)
- $X_8$ length of pukka road (0.54)
- $X_9$ agricultural labourers and workers (0.78)
- $X_{12}$ size of land holding (-0.84)

The values of the thirteen variables have been computed for 41 blocks for the year 1985-86 resulting in a 13 x 41
Table - 45

Factor structure of agricultural transformation in the Lower Ganga-Yamuna Doab through Rotated Factor Matrix, 1975-76

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor loadings</th>
<th>Variances explained in per cent</th>
<th>Cumulative percentage of variance explained</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( F_1 )</td>
<td>( F_2 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>( h^2 )</td>
<td></td>
</tr>
<tr>
<td>( X_1 )</td>
<td>0.96</td>
<td>0.15</td>
<td>62.03</td>
</tr>
<tr>
<td>( X_2 )</td>
<td>0.92</td>
<td>0.24</td>
<td>76.79</td>
</tr>
<tr>
<td>( X_3 )</td>
<td>0.92</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>( X_4 )</td>
<td>0.74</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>( X_5 )</td>
<td>0.93</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>( X_6 )</td>
<td>-0.05</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>( X_7 )</td>
<td>0.98</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>( X_8 )</td>
<td>-0.06</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>( X_9 )</td>
<td>0.31</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>( X_{10} )</td>
<td>0.27</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>( X_{11} )</td>
<td>0.96</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>( X_{12} )</td>
<td>-0.31</td>
<td>-0.84</td>
<td></td>
</tr>
<tr>
<td>( X_{13} )</td>
<td>0.97</td>
<td>0.14</td>
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</tr>
</tbody>
</table>

\( h^2 = \) Communalities
data matrix for the study region. This data matrix collapsed into each other leads to three factors of agricultural transformation. It shows that in all 84.15 per cent of the total variance is explained by these three factors (table 46). 62.07 per cent of the total variance is explained by F₁ which has a series of variables of heavy loadings. They are —

\[ X_1 \] tube-wells and pumping sets (0.90)  
\[ X_2 \] iron plough (0.92)  
\[ X_3 \] blade harrow and cultivators (0.93)  
\[ X_4 \] tractor power (0.82)  
\[ X_5 \] fertilizer consumption (0.93)  
\[ X_7 \] rural electrification (0.92)  
\[ X_{11} \] irrigation intensity (0.88)  
\[ X_{13} \] area under HYV seeds (0.92)

Factor F₂ accounts for 13.29 per cent of the total variance explained. It is heavily loaded on the variables —

\[ X_6 \] co-operative banks (0.70)  
\[ X_9 \] agricultural labourers and workers (0.77)  
\[ X_{10} \] literacy rate (-0.81)  
\[ X_{12} \] size of land holding (-0.74)

Factor F₃ which accounts for 8.79 per cent of the total variance explained has relatively heavy loadings on —

\[ X_8 \] length of pukka road (0.95) and  
\[ X_{12} \] size of land holding (-0.46)
Table - 46

Factor Structure of Agricultural Transformation in the Lower Ganga-Yamuna Doab Through Rotated Factor Matrix, 1985-86

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor loading</th>
</tr>
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<td>$F_1$</td>
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<td>$X_1$</td>
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<tr>
<td>$X_2$</td>
<td>0.92</td>
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<tr>
<td>$X_3$</td>
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<tr>
<td>$X_4$</td>
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<tr>
<td>$X_5$</td>
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</tr>
<tr>
<td>$X_6$</td>
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<tr>
<td>$X_7$</td>
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<tr>
<td>$X_8$</td>
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<tr>
<td>$X_9$</td>
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<tr>
<td>$X_{10}$</td>
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</tr>
<tr>
<td>$X_{11}$</td>
<td>0.88</td>
</tr>
<tr>
<td>$X_{12}$</td>
<td>-0.35</td>
</tr>
<tr>
<td>$X_{13}$</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Variance explained in 62.07 13.29 8.79 per cent.

Cumulative percentage of variance explained. 62.07 75.36 84.15

$h^2 = \text{Communalities.}$
Levels of Agricultural Transformation and their Technological Correlates:

This part of the chapter is attempted to analyse the levels of agricultural transformation and as to how it is influenced by the change in the magnitude of technological variables in the study region. To examine these points the approach of the author is trifocal. The first point deals with the regional patterns of decadal change in cultivated area during 1975-76 and 1985-86 and the influence of change in the selected technological variables on it. The second part is devoted to explain the change in agricultural production and as to how it is influenced by the change in technological variables selected. And finally the changing pattern of agricultural productivity is discussed and further it is correlated with the change in variables selected to explain their influence on agricultural productivity of the lower Ganga-Yamuna Doab.

In the analysis of this study block-wise change in cultivated area, total agricultural production and agricultural productivity have been correlated with all the thirteen independent variables by applying rank different correlation coefficient technique.

The block-wise distribution pattern of changed cultivated area in hectare during a decade (1975-76 to 1985-86) may be conveniently grouped into four grades of -2000 and
over, -2000 to 0, 0 to +2000 and above +2000. Figure 45 depicts that about three fourth of the blocks lie within a deviation of ±2000 hectares. But half of the blocks are at the negative side of the scale. It means these blocks have decreased the cultivated areas in the final year. It may be pointed out that about 12 per cent of the blocks of the study region has decreased the cultivated areas of more than 2000 hectares and 39 per cent of the blocks ranges between 0 and +2000 hectares. The same proportion of the blocks are found in the grade of positive direction (0 to +2000 hectares).

The blocks which have decreased the area under cultivation and have been put under the highest negative growth are Gheenjhak, Sandalpur, Chaubypur, Kalyanpur and Telyani. These blocks are scatteredly distributed in the western half of the study region where they fail to identify any distinct region.

The blocks which lie between the grade of -2000 to 0 hectares are Shivrajpur, Maitha, Akbarpur, Derapur, Sarvenkhera, Patara, Vidhnu, Amauli, Deomai, Asother, Kara, Airayan, Manjhanpur, Kaushambi, Muratganj and Chail. Out of these only seven blocks combinedly constitute a significant region in the western part of the lower Ganga-Yamuna Doab. The remaining blocks do not demarcate any region of negative change. These blocks are Kara (-1904 hectares), Muratganj (-1861 hectares),
Airayan (-1753 hectares), Amauli (-1448 hectares), Deomai (-1077 hectares), Chail (-745 hectares), Manjhanpur (-363 hectares, Asother (-187 hectares) and Kaushambi (-149 hect.).

The blocks lying between the grade of 0 to + 2000 are Ghatampur, Rajapur, Malasa, Amraudha, Rasulabad, Kakvan, Bheetargaon, Sarsaul, Khajuha, Malvan, Bahuva, Hasva, Vijaypur, Sirathu, Sarsava and Nevada. Among these only six blocks combinedly constitute a dominant region in the western part and five blocks constitute a distinct region in the central part of the lower Ganga-Yamuna Doab. The remaining blocks of this grade do not demarcate any region (Figure 45).

The blocks which have increased the area under cultivation and have been put under the highest positive growth (2000 hectares and over) are Bilhaur, Bhitaura, Hathgaon and Dhata. These blocks are scatteredly distributed in the eastern half of the study region except block Bilhaur which lies in the north-western part of the lower Ganga-Yamuna Doab where they fail to identify and distinct region.

The study reveals that the transformation in cultivated area in the lower Ganga-Yamuna Doab is not only due to the result of changes in technological factors of agricultural transformation, because more than half of the changed technological factors are not directly proportional to the area transformed. The decrease in the cultivated area in some blocks are due to the result of decrease in areal extent of
certain crops such as jwar bajra, barley, pulses and in some cases oilseeds and rice. The change in the cultivated area of the blocks up to some extent is influenced by the changed technological variables, therefore, the changed cultivated area ($Y_1$) is correlated with the other independent variables (table 47).

It is found that about half of the variables of agricultural transformation are directly proportional to the changed cultivated areas but their rates of change are dissimilar (table 47). Size of landholding ($X_{12}$) is the only variable which has high degree of positive relationship with ($Y_1$). The variables which have negative and weak correlation with ($Y_1$) are $X_1(-0.02)$, $X_2(-0.03)$, $X_3(-0.08)$, $X_4(-0.06)$, $X_5(-0.08)$, $X_8(-0.33)$ and $X_9(-0.25)$.

The changed agricultural production has given the positive response among all the blocks of the study region. It has also a wide range of variations among the blocks. It may be arranged into four grades (in 000 quintals) of below 150, 150 to 300, 300 to 450 and 450 to 600.

The blocks which have lowest increase of agricultural production (below 1,50,000 quintals) are Derapur (1,46,493 quintals), Shivrajpur (1,43,911 quintals), Khajuha (12,068 quintals) and Muratganj (1,05,808 quintals). These blocks combinedly fail to identify any distinct region.
<table>
<thead>
<tr>
<th>X</th>
<th>x_1</th>
<th>x_2</th>
<th>x_3</th>
<th>x_4</th>
<th>x_5</th>
<th>x_6</th>
<th>x_7</th>
<th>x_8</th>
<th>x_9</th>
<th>x_{10}</th>
<th>x_{11}</th>
<th>x_{12}</th>
<th>x_{13}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y_1</td>
<td>-0.02</td>
<td>-0.03</td>
<td>-0.08</td>
<td>-0.06</td>
<td>-0.08</td>
<td>0.05</td>
<td>-0.33</td>
<td>-0.25</td>
<td>0.02</td>
<td>0.19</td>
<td>0.56</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Y_2</td>
<td>0.06</td>
<td>0.05</td>
<td>0.05</td>
<td>-0.08</td>
<td>-0.05</td>
<td>0.09</td>
<td>-0.28</td>
<td>-0.27</td>
<td>0.30</td>
<td>0.07</td>
<td>0.05</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Y_3</td>
<td>0.49</td>
<td>0.64</td>
<td>0.41</td>
<td>0.53</td>
<td>0.28</td>
<td>0.70</td>
<td>-0.13</td>
<td>0.06</td>
<td>0.13</td>
<td>0.72</td>
<td>-0.21</td>
<td>0.61</td>
<td></td>
</tr>
</tbody>
</table>

Y_1 = Changed cultivated area.
Y_2 = Changed agricultural production.
Y_3 = Changed agricultural productivity.
About fifty per cent of the blocks lie between the grade of 1,50,000 and 3,00,000 quintals increase in agricultural production. These blocks form two distinct regions in lower Ganga-Yamuna Doab. One lies in the Western part and includes seven blocks of Sandalpur, Gheenjhak, Rasulabad, Kakvan, Chaubypur, Bilhaur and Kalyanpur. The other region occurs in the eastern half of the Doab (Figure 46).

Twelve blocks are lying between the grade of 3,00,000 and 4,50,000 quintals. These are Amraudha, Rajapur, Malasa, Gheenjhak, Akbarpur, Maitha, Sarvankhera, Vidhnu, Sarsaul, Malvan, Telyani and Dhata. Three-fourth of these together constitute a significant region in the western part of the lower Ganga-Yamuna Doab. The other two blocks lie in the central part along the river Ganga and one block in the eastern part along the river Yamuna.

The blocks which have the highest positive growth (4,50,000 quintals and above) of agricultural production are Bheetargaon, Amauli, Deomai and Sarsava. The first three blocks constitute a small region in the central part of the lower Ganga-Yamuna Doab. Figure 46 gives a plausible explanation.

It may be summarized that there is an increase in agricultural production in all the blocks of the study region. In a little less than 10 per cent of the blocks the production
LOWE R GAN G A-YAMUNA DOAB
CHANGED AGRICULTURAL PRODUCTION
1975-76 TO 1985-86

INDEX
In 000 quintals

450 - 600
300 - 450
150 - 300
BELOW 150

Kilometres

* A TOWN AREA OF KANPUR

FIG. 46
is raised by above 450 thousand quintals and in 29 per cent of the blocks it is from 300 thousand to 450 thousand quintals, whereas half of the blocks lie between 150 thousand and 300 thousand quintals of agricultural production and only one-tenth of the blocks are found in the grade of 150 thousand quintals and below.

While examining the relationship between the changed agricultural production and magnitude of changed independent variables, it is found that there is very low degree of relationship. It clearly shows that the rate of change in technological correlates of different blocks are not directly proportional to the block-wise changed agricultural production of the study region. Table 47 reports that higher is the change in agricultural production lower is the change in length of pukka road \( (X_8) \) and agricultural labourers and workers \( (X_9) \) and vice-versa. Change in the literacy rate \( (X_{10}) \) is directly related with changed agricultural production. Besides, two-third of the correlates have positive degree of relationship with agricultural production but they are far below the confidence level.

Changed agricultural productivity \( (Y_2) \) in terms of Yang's Yield Index is the third aspect of agricultural transformation. It has a wide range of variations among the blocks of the study region. For the sake of convenience it has been grouped into five grades of -10 and above, -10 and 0, 0 and +10, +10 and +20 and over (figure 47).
The blocks which have decreased the agricultural productivity index more than 10 are Jheenjhak, Bilhaury, Kalyanpur, Vidhnu and Sarsaul. The later four blocks lying along the river Ganga constitute a region of negative growth of agricultural productivity in the western part. The remaining block is lying in the extreme west of the lower Ganga-Yamuna Doab.

Only three blocks fall in the grade of -10 to 0 are Amauli, Asother and Nevada. They are scattered in the central and eastern parts of the study region along the river Yamuna where they fail to identify any distinct region.

About forty six per cent of the blocks have marginal positive growth of agricultural productivity (0 to 10 index). These blocks formed three distinct regions in the lower Ganga-Yamun Doab. First lies in the south-western part and it composed to Derapur, Rajapur, Malasa and Sarvankhera blocks. Second region is found in the central part and includes the blocks of Khajuha, Malvan and Bahuva. And the third region occurs in the eastern part which is relatively dominant and comprises Bhitaure, Hathgaon, Vijapur, Dhata, Kara, Sirathu, Muratganj and Manjhanpur blocks. The remaining blocks are scattered in the central and western parts of the study region.
About twenty five per cent of the blocks are considered under the grade of +10 to +20. They are Sandalpur, Rasulabad, Kakvan, Akbarpur, Gheenjhak, Patara, Airayan, Vijaypur and Chail. These blocks do not form any distinct region.

The blocks which have been put under the highest positive growth of agricultural productivity (20 and above are Chaubypur (22.76), Deomai (26.27), Hasva (29.35) and Sarsava (20.48). These blocks are far apart from each other.

It may be pointed out briefly that about 12 per cent of the blocks of the study region have changed productivity indices above -10. Figure 47 depicts that above 50 per cent of the blocks lie within a deviation of ±10. But 15 per cent of the blocks are at the negative side of the scale which have decreased the productivity indices in the final year. In 27 per cent of the blocks productivity indices ranges between 10 and 20. In about 10 per cent of the blocks it is above 20.

The relationship between changed index of agricultural productivity ($Y_3$) and the independent variables has been computed with the assumption that linear relationship exit in all the cases.

It may be pointed out that fifty per cent of the variables have the high degree of positive relationship with ($Y_3$) and are significant at one per cent level. These variables are
LOWER GANGA-YAMUNA DOAB
CHANGED AGRICULTURAL PRODUCTIVITY
1975-76 TO 1985-86

INDEX

- ABOVE 20
- 10 TO 20
- 0 TO 10
- -10 TO 0
- ABOVE -10

T.A. TOWN AREA OF KANPUR

FIG 47
tube-wells and pumping sets ($X_1$), iron plough ($X_2$), blade harrow and cultivators ($X_3$), tractor power ($X_4$), rural electrification ($X_7$), irrigation intensity ($X_{11}$) and area under HYV seeds ($X_{13}$). The variables which have negative correlation and are far below the significant level of confidence are length of pukka road ($X_8$), literacy rate ($X_{10}$) and size of land holding ($X_{12}$). These variables show that higher the rate of change in agricultural productivity lower is the rate of change in variables length of pukka road ($X_8$), literacy rate ($X_{10}$) and size of land holding ($X_{12}$) and vice-versa. It may be further explained that the changed technological correlates i.e., length of pukka road ($X_8$), literacy rate ($X_{10}$) and size of land holding ($X_{12}$) are inversely proportional to the changed indicies of agricultural productivity.
IMPACT OF BIOTECHNOLOGY ON CROP PRODUCTION
IN LOWER GANGA-YAMUNA DOAB

With the new knowledge gained by the scientists about the functioning of the nature's living system, the world is at the threshold of a new revolution, which has been aptly called "biorevolution" or "generevolution". With the recent developments in electronics, computers and instrumentations, the scientists and technologists are able not only to understand the minutest of the minute microorganisms, but are also to analyse and manipulate them. This capability has opened up entirely new and hitherto unknown opportunities for finding unimaginably easy solution to the multitudes of problems being faced in areas of agricultural productivity, food, health care, bio-mass regeneration, environmental management, population control.

One of the major problems, which developing countries like India are constantly facing, is that of feeding their millions. The majority of the people in India cannot even get the minimum required calories of proteins, while, pressures on land have increased to such levels that environmental imbalance has already occurred. The new biotechnology techniques, now available, hold out a definite promise, particularly for the third world countries towards increasing their agricultural and farm productivity, availability of new protein rich food products and utilization of waste material for feed and energy.
Agriculture has moved from a resource based to a science based industry as technology yields quicker and far better results than manual labour. Biotechnology has been defined as 'any technique that uses living organisms, or substances from those organisms to make or modify a product, to improve plants or animals, or to develop microorganisms for specific use.' The term covers a continuum of technologies that ranges from long-established and widely used technologies based on commercial use of living organisms (such as brewing, biological control of pests, and conventional animal vaccine production), through genetic engineering of plants and animals.

In India, bio-technology is defined as "the application of biological organisms and molecules to technical and industrial processes. It generally implies the application of novel microbes or other living systems altered or modified by humans by various techniques of genetic engineering, cell fusion etc." Thereafter hybridoma techniques creation of monoclonal antibodies has paved the way for exploitation of technology for producing in large quantities, at a comparatively much cheaper cost, many useful and essential items like growth hormones, tissue culture plants, embryo transfer technology, stress and disease resistant plants.


Biotechnology offers tremendous potential for improving crop production, animal agriculture and bioprocessing. It can prove new approach to develop higher yielding and more nutritious crop varieties, improve resistance to diseases under adverse conditions, or reduce the need for chemical fertilizers and other expensive agricultural chemicals.

The tools of biotechnology offer both a challenge and tremendous opportunity. They offer new techniques for manipulating genes of plants. Biotechnology tools complements, rather then replace, the traditional methods, used to enhance agricultural productivity and build on a base of understanding derived from traditional studies in biology, genetics, physiology and biochemistry.

**Genetic Engineering of Plants:**

Perhaps the most direct way to use biotechnology to improve crop agriculture is to genetically engineer plants, i.e., alter their basic genetic structure, so they have new characteristics to improve the efficiency of crop production. The traditional goal of crop production remains unchanged: to produce more and better crops at lower cost. However, the tools of biotechnology can speedup the process by helping the researchers screen generations of plants for a specific traits or work more quickly and precisely to transfer a trait. These tools give breeders and genetic engineers access to a wider universe of traits from which to select.
Although powerful, the process is not simple. In the first place the gene of interest has to be isolated, insert it into a plant cell, induce the transformed cell to grow into an entire plant, and then make sure that the gene is appropriately expressed. It has been successfully demonstrated how plant can be genetically engineered to benefit agriculture. Herbicide resistance traits are being transformed to increase option for controlling weeds. Soon, the composition of storage proteins, oils and starches in plants may be altered to increase their values.

Genetic engineering has for the first time engineered plants to be resistant to powerful herbicides. One example is glyphosate (trade name: "Roundup"), a common, effective and environmentally safe herbicides. However, glyphosate indiscriminately kills crops as well as weeds. Thus, it must usually be used before crop plants germinates. Yet by engineering crops to be resistant to glyphosate, it is hoped to expand the range of the herbicide's applications.

Plant cannot directly absorb and use nitrogen gas present in the atmosphere. To be available to plants, nitrogen gas must first be "fixed", or converted into nitrogen compounds either by industrial processes or by certain bacteria and blue-green algae that live in the soil. The most well known bacteria able to fix nitrogen belong to the genus Rhizobium, which is associated with members of the legume family such as
soyabean, beans, peas and peanuts. Genetic engineering finds ways to improve nitrogen fixation in these plants. This development could play a critical role in lowering the production costs by reducing the need for energy inputs used in producing nitrogen fertilizers.

Researchers are pursuing a number of different strategies to improve nitrogen fixation. Perhaps the simplest approach is to improve the symbiotic relationship now found in nature — to genetically engineer Rhizobium to fix nitrogen more efficiently for their natural host legumes. A second approach would be to create Rhizobium that could infect and fix nitrogen for other plants, in particular to cereal crops. Alternately, it might be possible to transfer the ability to fix nitrogen to other microorganism, that already live in association with a given crop. Another approach involves trying to engineer plants to fix nitrogen themselves.

**Genetic Engineering for Crop Protection:**

Another strategy to improve crop production through genetic engineering involves protecting crops from pests. Insects, virus, bacteria, fungi, nematodes and weeds can all impair agricultural production. Yet in the natural ecosystem organisms typically serve many functions. Insects, for example, can be pests which destroy crops and stored products by transmitting diseases.

Most of the chemical insecticides, herbicides and other pesticides that have been primary methods of controlling
pests are not selective enough to affect only harmful organism. As biotechnology becomes more refined, methods for handling bothersome pests and beneficial organisms will be created.

One area in which genetic engineering technology will prove particularly useful is in developing biological pests control methods. Insects are attracted to certain plants and repelled by others. Some plants produce chemicals that mimic insect harmones and disrupt the reproduction of insects feeding on the plants. Thus, the potential exists to identify the genes controlling the properties and transfer these traits to other plants.

Insect harmones are already used in small quantities in pest management. Pheromones, for example, are used as attractants in traps that monitor levels of insect populations. Conversely, alaromones can be used to repel insects from stored products. Ultimately, as genetic engineers increase their skills, they may be able to alter crops so that they can produce their own insect repellant.

Some advanced use of harmones for biological pest control are already available. Juvenile harmones analogues are synthetic chemical compounds similar to the natural harmones that controls maturation of insects. When the Juvenile harmones analogue is sprayed on an insect, it remains in an immature state and dies instead of maturing and reproducing.
Another experiment of potential importance for insect control involves a genetically altered bacterium. The organism, a strain of corn root colonizing bacteria called pseudomonas fluorescens has been genetically changed so it produces an endotoxin that is a potent insecticide for certain pests, including black cutworm. The gene to produce toxin was transferred from another bacterium, Bacillus thuringiensis, which itself has been marketed as a biological insecticides for more than 20 years. The recombined bacterium can be frozen, dried and coated directly on seeds before planting, or it can be sprayed into the fields.

Naturally occurring insect pathogens, including bacteria, viruses, and fungi, have served for many years as agents of biological pests control, but problems with production, application and efficiency have prevented their widespread use. However advances in genetic engineering are opening routes to manipulate these organism into more useful tools for biological insect control on a large scale.

A more speculative approach to insect control is the use of modified plant viruses that are usually spread by insects. In this strategy the specific toxin gene of an insect or behavior-modifying gene would be inserted into a genome of the plant virus, so it is expressed in the cells of the carrier insects. This approach might be a method of controlling sucking insects.
Research in this direction in India is being conducted at Indian Council for Agricultural Research (IARI), Tamil Nadu Agricultural University (TNAU), National Centre for Integrated Pest Management (NCIPM), Haryana Agricultural University (HAU), Gujrat Agricultural University (GAU) etc. To identify possibilities of developing biocontrol agents against major pests, diseases and weeds, a task force was set up by the Department of Biotechnology. The task force has also recommended the establishment of pilot plants for the production of already proven efficient microbes.

The most widely used method of creating crops with combinations of new characters is through hybridizations where different parents with the desirable features are crossed. The use of hybrid vigors in crops has successfully increased yields over the years. However, most of these technologies were largely limited to a single species and were imprecise.

Tissue culture is a technique by which individual cells or tissues of plants can be cultured artificially under aseptic conditions to regenerate whole plants. The rate of multiplication could be several hundred-fold. Also the plants could be raised independent of seasonal vagaries in limited space.

The United States Office of Technology and Assessment, whose detailed studies have provided one of the most reliable estimates of likely impact, considers that over the next
decade the major impact of agricultural biotechnology will be seen on crop production — on average, yield of major crops are expected to increase 1.2 per cent per annum for cereals and 0.7 per cent for cotton. In the absence of the development and use of new biotechnologies yield increase would be only between one quarter and one half of these.³

**Application of Biotechnology to Crops in Lower Ganga-Yamuna Doab:**

By the application of biotechnology as a tool of crop improvement in different blocks of lower Ganga-Yamuna Doab keeping all other agricultural inputs as constant, the production of major food crops can be raised upto considerable extent as shown in table 48.

**Table - 48**

Estimated increase in cereals production and supporting the population of lower Ganga-Yamuna Doab with the application of biotechnology.

<table>
<thead>
<tr>
<th>Name of the Block</th>
<th>Estimated increase of cereals production (in quintals)</th>
<th>Additional population can be supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghatampur</td>
<td>3,876</td>
<td>2,655</td>
</tr>
<tr>
<td>Patara</td>
<td>3,906</td>
<td>2,673</td>
</tr>
<tr>
<td>Bheetargaon</td>
<td>4,342</td>
<td>2,974</td>
</tr>
<tr>
<td>Amraudha</td>
<td>2,427</td>
<td>1,662</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajapur</td>
<td>2,841</td>
<td>1,974</td>
</tr>
<tr>
<td>Malasa</td>
<td>3,292</td>
<td>2,255</td>
</tr>
<tr>
<td>Akbarpur</td>
<td>4,090</td>
<td>2,801</td>
</tr>
<tr>
<td>Maitha</td>
<td>4,679</td>
<td>3,205</td>
</tr>
<tr>
<td>Sarvankhera</td>
<td>4,726</td>
<td>3,237</td>
</tr>
<tr>
<td>Derapur</td>
<td>2,625</td>
<td>1,798</td>
</tr>
<tr>
<td>Rasulabad</td>
<td>3,850</td>
<td>2,637</td>
</tr>
<tr>
<td>Gheenjhak</td>
<td>3,048</td>
<td>2,088</td>
</tr>
<tr>
<td>Sandalpur</td>
<td>2,412</td>
<td>1,652</td>
</tr>
<tr>
<td>Bilhaur</td>
<td>3,426</td>
<td>2,347</td>
</tr>
<tr>
<td>Chaubypur</td>
<td>3,529</td>
<td>1,732</td>
</tr>
<tr>
<td>Kakvan</td>
<td>3,477</td>
<td>2,382</td>
</tr>
<tr>
<td>Shivrajpur</td>
<td>3,251</td>
<td>2,254</td>
</tr>
<tr>
<td>Kalyanpur</td>
<td>3,303</td>
<td>2,262</td>
</tr>
<tr>
<td>Sarsaul</td>
<td>5,051</td>
<td>3,460</td>
</tr>
<tr>
<td>Vidhnu</td>
<td>4,800</td>
<td>3,288</td>
</tr>
<tr>
<td>Amauli</td>
<td>3,473</td>
<td>2,379</td>
</tr>
<tr>
<td>Khajuha</td>
<td>4,330</td>
<td>2,966</td>
</tr>
<tr>
<td>Deomai</td>
<td>3,514</td>
<td>2,407</td>
</tr>
<tr>
<td>Malwan</td>
<td>4,783</td>
<td>3,276</td>
</tr>
<tr>
<td>Telyani</td>
<td>3,977</td>
<td>2,724</td>
</tr>
<tr>
<td>Bahuva</td>
<td>3,912</td>
<td>2,679</td>
</tr>
<tr>
<td>Bhitaura</td>
<td>4,785</td>
<td>3,277</td>
</tr>
<tr>
<td>Hasva</td>
<td>4,492</td>
<td>3,077</td>
</tr>
<tr>
<td>Asother</td>
<td>4,187</td>
<td>2,868</td>
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<td>(1)</td>
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<td>(3)</td>
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<td>----------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Hathgaon</td>
<td>3,640</td>
<td>2,492</td>
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<tr>
<td>Airayan</td>
<td>4,103</td>
<td>2,810</td>
</tr>
<tr>
<td>Vijaipur</td>
<td>3,299</td>
<td>2,260</td>
</tr>
<tr>
<td>Dhata</td>
<td>2,104</td>
<td>1,441</td>
</tr>
<tr>
<td>Chail</td>
<td>2,697</td>
<td>1,847</td>
</tr>
<tr>
<td>Nevada</td>
<td>2,820</td>
<td>1,932</td>
</tr>
<tr>
<td>Muratganj</td>
<td>2,409</td>
<td>1,650</td>
</tr>
<tr>
<td>Kaushambi</td>
<td>2,584</td>
<td>1,770</td>
</tr>
<tr>
<td>Manjhanpur</td>
<td>2,084</td>
<td>1,427</td>
</tr>
<tr>
<td>Sarsava</td>
<td>2,918</td>
<td>1,999</td>
</tr>
<tr>
<td>Kara</td>
<td>2,736</td>
<td>1,874</td>
</tr>
<tr>
<td>Sirathu</td>
<td>3,488</td>
<td>2,389</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,45,312</td>
<td>99,529</td>
</tr>
</tbody>
</table>

**The statistics relating to estimate increase of crop production has been computed by the author, on the basis of the assumed increase in yield of cereals proposed by Gabrielle of Canberra, (Australia).

The additional population that can be fed with the increase in food production has been calculated by the author taking average of 400 grams of cereals to suffice one person per day. 400 grams of cereals (the average for India) will approximately yield 1,400 calories of wheat, the most predominant cereal is taken as the base.
From table 48 it can be seen that the total food crop production of the lower Ganga-Yamuna Doab is likely to be increased by 1,45,312 quintals and about 1,00,000 additional person can be supported if biotechnological methods are applied in the region. Block Manjhanpur will have least increase in cereal crops production which will support an additional population of 1,427 persons and block Vidhnu will have highest increase in cereals production which will support an additional population of 3,288 persons. The remaining blocks of the study region lie in between this range.

Biofertilizers:

It has been projected that by 2000 AD, foodgrain production in India would need to be augmented to the order of 240 million tonnes. This order of agriculture production can be achieved through large scale application of chemical fertilizers. The fertilizer sector would, therefore, need an additional investment of Rs.8,000 - 10,000 crores (4 to 5 billion). Additionally, negative effects of chemical fertilizers on the physico-chemical properties of soil are well known. Chemical fertilizers are also increasingly expensive because of high infrastructural cost, fossil-fuel shortage and energy intensive process for manufacturing. Under the
circumstances appropriate approach will be integrated through blending of chemical, organic and biofertilizers.

In order to lessen dependence entirely on energy and cost intensive fertilizer, steps have been taken towards tapping biological nitrogen fixation through symbiotic and non-symbiotic bacteria, blue-green algae, rhizobium and azolla.

It has been pointed out that the livestock excreta if cycled through anaerobic fermentation in gobar gas plants could provide simultaneously manure and gas energy for rural households.

This is necessary as at present out of a total of 650 million tonnes of rural compost only 263 million tonnes or about 40 per cent of it are used and of the 16 million tonnes of urban compost just six million tonnes or about 37 per cent are utilized.

It is necessary that a conscious effort has made to promote multipurpose leguminous shrubs and trees to rehabilitate vast areas of degraded lands in the country, recoup soil fertility and minimise the input of chemical fertilizers.

The consumption of chemical fertilizers has made rapid strides since the mid-sixties. It has been estimated that their requirement by 1994-95 be of the order of 17.5 million
tonnes to meet the target of 205 million tonnes of food-grains. This is as against the current level of consumption which has touched 11.7 million tonnes in 1989-90.

Biofertilizers are biologically active products or whole microbial inoculants of bacteria, algae, fungi, alone or in combination which augment the extent of availability of nutrients to the plants.

There are various biofertilizers in use such as culture of Rhizobium, Azotobacter, Azospirillum, Blue-green algae, Azolla and Phosphate-solubilizing microorganism. The technology now is available for producing seeds pre-coated with the inoculant, which increases its efficiency.

The benefits derived by agricultural crops from microbial inoculants in the study region would be approximately equivalent to the output derived from the application of 30 to 40 kg N/hectare. On this basis it is estimated that 42 to 57 million tonnes of chemical fertilizers consumption can be curtail annually by using biotechnology in the lower Ganga-Yamuna Doab.

The beneficial effect of the biofertilizers are evident from table 49.
It will be seen from the table 49 that with the application of biofertilizers, the production of gram is raised by 13.9 per cent, arhar (pigeon pea) 9.9 per cent, rice 11.4 to 24.3 per cent, sorghum 18.2 per cent, bajra 25.1 per cent and cotton 6.8 per cent.

In India a considerable research and development work of rhizobium is being conducted at Indian Agricultural Research
Institute, Haryana Agricultural University, Punjab Agricultural University and G.B.Pant Agricultural University. Presently rhizobium cultures for crops like masoor, barseem, groundnut arhar, moong pea, gram, urd and soyabean are available.

Field experiments show an increase in the yield of wheat, rice, onion, brinjal, tomato and cabbage as a result of Azotobacter inoculation. It has been shown that in areas where nitrogen fertilizers are scarcely used, blue-green algae can supply 20 to 30 kg N/ha./Yr.

Research conducted at Indian Agricultural Research Institute using phosphobacterin on wheat, barseem, maize, arhar and rice showed significant increase in yield over uninoculated controls. The work on Azolla is being conducted at CPRI, Cuttack.

Lower Ganga-Yamuna Doab has 238 thousand hectares of land under pulses cultivation, 213 thousand hectares under rice cultivation, 57 thousand hectares under bajra cultivation, 72 thousand hectares under jwar cultivation and 6,874 thousand hectares under wheat cultivation. The application of biofertilizers may be of great assistance in raising the yield of cereals.

By the application of biofertilizers in the study region, the production of crops are likely to increase up to a considerable extent. Production of rice is estimated to increase by 713 thousand quintals, jwar 93 thousand quintals, bajra 151 thousand quintals and pulses 284 thousand quintals. Thus it
can be said that by application of biofertilizers, the production of rice, jwar, bajra and pulses alone can raise the agricultural production in the study region by more than 1241 thousand quintals. Besides these crops, production of wheat, groundnut and soyabean can also be raised. This increased production of rice, jwar and bajra will support an additional population of a little more than 6.5 lakh and the increased production of pulses will be consumed by an additional population of 11.1 lakh in the lower Ganga-Yamuna Doab. Thus we can say that by the application of biotechnology, as a tool, for crop improvement and biofertilizers, the agricultural production of the study region can be increased upto a considerable extent. The increased cereals production will be of the order of tonnes to feed 7.5 lakh additional (750 thousand) months and the increased production of pulses will sustain 1.11 million additional population of the lower Ganga-Yamuna Doab.